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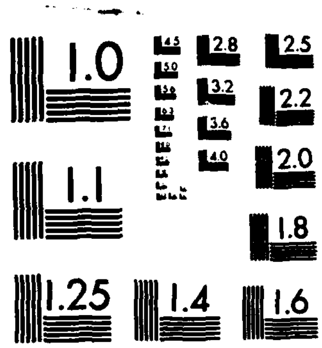

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FOREWORD

In this report, the authors describe an efficient computer program to compute geocentric tides along satellite tracks from prepared harmonic tidal constants computed on a standard satellite track grid system. The program is an improved version of a preliminary program, which has been applied to compute instantaneous geocentric tides along SEASAT tracks.

This project was supported by the Naval Surface Weapons Center's Independent Research Fund and by a grant from the National Geodetic Survey of the Department of Commerce/NOS/NOAA.* It is the author's most pleasant obligation to acknowledge the sustained and generous sponsorship of Mr. O. F. Braxton, Head of the Strategic Systems Department, his Associate, Dr. R. J. Anderle, and Mr. C. W. Duke, Jr., Head of the Space and Surface Systems Division. Many critical and stimulating suggestions were gratefully received from the authors' colleagues, Drs. C. J. Cohen, and B. Zondek.

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*National Ocean Survey (NOS)
National Oceanographic and Atmospheric Administration (NOAA)

CONTENTS

ABSTRACT

In the following report, the authors present three computer programs to compute geocentric tides including ocean and earth tides and ocean-loading effects along "parallel" satellite tracks from the harmonic ocean tidal constants listed on the NSWC GOTD Tape (Schwiderski and Szeto 1981). The first program prepares a basic standard satellite track (SST), which is shifted parallel to itself to define a 1° x 1° SST grid system. The second program computes harmonic geocentric tide data at all SST grid points, which are stored on three magnetic tapes (SST GTD Tapes I, II, and III). From the prepared SST GTD tapes, the third (STT) program computes instantaneous tides along parallel satellite tracks by a smooth and fast interpolation scheme. All three programs eliminate various input-error possibilities of their preliminary versions, which have been applied to compute instantaneous geocentric tides along SEASAT tracks. The program descriptions include corresponding User's Guides and Program Listings. An extended version of the STT program is in preparation. It will include group beat effects on all major tidal components by frequency-wise neighboring minor tidal modes.

1. INTRODUCTION

In an earlier report, the authors (Schwiderski and Szeto 1981) described briefly the major features of the NSWC ocean tide models (Schwiderski 1978a, b, 1979a - e, 1980, 1981a - k, 1982a - d), which require indispensable consideration in various applications. In particular, suggestions were discussed to improve the model accuracy especially in coastal waters. These general discussions were followed by a detailed description of the arrangement and format of the NSWC Global Ocean Tide Data (GOTD) Tape (Schwiderski 1981k), which contains the $1^\circ \times 1^\circ$ gridded harmonic ocean tide constants, i.e., amplitudes and phases.

Using the NSWC GOTD 1981 tape, a Random-Point Tide (RPTIDE) program was elaborated complete with User's Guide and Program Listing. The RPTIDE program computes oceanic and/or geocentric (including earth tides and loading effects) tides at randomly specified geographical points and instances. Since the required GOTD 1981 tape contains over one million data, the general RPTIDE program is cost-wise limited to a relatively small number of random points. It is definitely far too expensive and time consuming to compute, for instance, geocentric tidal heights along satellite tracks, which carry altimeters to measure the instantaneous sea surface height underneath the satellite every half second or so.

It is the purpose of the present report to present the special NSWC Satellite Track Tide (STT) program, which computes efficently geocentric tidal heights along tracks of altimeter-carrying satellites at the instances sea-surface measurements are being taken. It makes effective use of the fact that the ground tracks of satellites with identical and fixed-orbit parameters are essentially "parallel" to each other (see Figure 2). Indeed, disregarding negligible deviations, two consecutive satellite orbit tracks are congruent to each other in space and time, they differ only in a uniform longitudinal westward shift.

In Section 2, one finds a detailed description of the NSWC SST program and grid system, which generates from an approximately given standard satellite orbital ground track, a (basic) SST upon which the basic SST grid system is defined. Section 3 presents, in detail, the NSWC Standard Satellite Track Geocentric Tide Data (SST GTD) program, which converts the NSWC Global Ocean Tide Data (GOTD 1981) from its $1^\circ \times 1^\circ$ spherical grid to the new SST grid system defined in Section 2. The generated new geocentric tide data are stored on three magnetic tapes (NSWC SST GTD Tapes I, II, and III) described in Section 4. These tapes are used in the NSWC STT program described in Section 5, which computes instantaneous geocentric tides along specified congruent satellite tracks. Finally, the Appendixes A, B, and C contain the corresponding User's Guides and Program Listings of all three NSWC programs (SST, SST GTD, and STT programs).

2. NSWC STANDARD SATELLITE TRACK (SST) PROGRAM AND GRID SYSTEM

The NSWC SST program generates from a given approximate standard satellite ground track between two consecutive ascending nodal points a basic SST, which serves as the basis of the SST grid system defined below.

Definition of ESST and ASST

An "exact" standard satellite track (ESST) is defined as a nonequatorial one-revolution ground track of a satellite (say, SEASAT or GEOS-3) traveling westward around the earth between two consecutive ascending nodal points both "exactly" on the equator. If one or both nodal points deviate slightly off the equator, the track is called "approximate" standard satellite track (ASST).

A. Input Data (ASST)

An ASST is specified by:

(1) (λ_j, ϕ_j) = longitudes (East, $0° \leq \lambda_j \leq 360°$) and latitudes (North, $-88° \leq \phi_j \leq +88°$) of $j = 1, 2, 3, \ldots, 381$ ASST points, which are uniformly spaced by the constant travel time $\Delta\tau = \hat{\tau}/380$, where

(2) $\hat{\tau}$ = orbital period (in sec)

The input data (1) and (2) ***must*** satisfy the following ASST accuracy conditions.

(a) The λ_j, ϕ_j, $\hat{\tau}$ values ***must*** be given to $0.5 \cdot 10^{-3}$ degrees and seconds, respectively.

(b) The exact ESST condition

$$\phi_1 = \phi_{381} = 0 \tag{1}$$

is in practical applications usually not fulfilled. However, the ***minimum*** approximate condition

$$|\phi_1| < 0.5° \text{ and } |\phi_{381}| < 0.5° \tag{2}$$

can and ***must*** be enforced to avoid significant losses in accuracy. The SST program checks this condition (see B. below) and rejects the given ASST in case of its violation.

Note 1: The Pole regions are excluded ($|\phi_i| \leq 88°$) to avoid, singularities in the grid system. The 381 spacing points along the ASST have been chosen to make the geographical distance between two consecutive points about equal to a one-degree equatorial distance. Of course, any other number of points could be chosen in principle.

B. Main Computation:

The following procedure generates from the given ASST an ESST, which is needed for the largest-integer arithmetic in the STT program of Section 5. This procedure simply shifts all track points along the corresponding parabolic tangents, in order to enforce Equation (1) while maintaining a constant but slightly adjusted travel time between the new consecutive track points (see Figure 1). At the same time the program shifts the resulting ESST to the Equator-Greenwich-Meridian intersection and augments the track by one skew-symetric additional point at each end. This completes the desired generation of the (basic) SST upon which the definition of the SST grid system is based (see Figure 2). The added two points simplify the practical application of the STT program of Section 5.

(1) Check for

$$|\phi_1| < 0.5 \text{ and } |\phi_{381}| < 0.5$$

if violated, reject given ASST, otherwise compute:

$$\Delta\tau = \hat{\tau}/380$$
$$\Delta\lambda_1 = \lambda_1 - \lambda_2 \ (+360 \text{ if} < 0)$$
$$\Delta\phi_1 = \phi_2 - \phi_1$$
$$\Delta\lambda_{381} = \lambda_{380} - \lambda_{381} \ (+360 \text{ if} < 0)$$
$$\Delta\phi_{381} = \phi_{381} - \phi_{380}$$
$$\Delta\tau_1 = \Delta\tau\phi_1/\Delta\phi_1$$
$$\Delta\tau_{381} = \Delta\tau\phi_{381}/\Delta\phi_{381}$$
$$\hat{\tau}' = \hat{\tau} - (\Delta\tau_{381} - \Delta\tau_1)$$
$$\widetilde{\Delta\tau} = (\Delta\tau_{381} - \Delta\tau_1)/380$$
$$V = \frac{1}{\Delta\tau}\left[(\Delta\lambda_1)^2 + (\Delta\phi_1)^2\right]^{1/2}$$
$$\lambda = 360 - \lambda_1 - \phi_1\Delta\lambda_1/\Delta\phi_1)$$
$$\lambda'_{382} = \left[\lambda + \lambda_{381} + \phi_{381}\Delta\lambda_{381}/\Delta\phi_{381}\right] \bmod 360, \ (0 \leq \lambda' \leq 360)$$

(2) For j = 2, 3, ..., 380 compute consectively:

$$\Delta\tau_j = \Delta\tau_{j-1} + \widetilde{\Delta\tau}, \ (\Delta\tau_1 \text{ see above})$$
$$\Delta\lambda_j = \lambda_{j-1} - \lambda_{j+1} \ (+360 \text{ if} < 0)$$
$$\Delta\phi_j = \phi_{j+1} - \phi_{j-1}$$

$$S_j = V\Delta\tau_j/[(\Delta\lambda_j)^2 + (\Delta\phi_j)^2]^{1/2}$$
$$\lambda'_{j+1} = (\lambda_j + S_j\,\Delta\lambda_j + \lambda) \mod 360, (0 \leqslant \lambda' \leqslant 360)$$
$$\phi'_{j+1} = \phi_j - S_j\,\Delta\phi_j$$

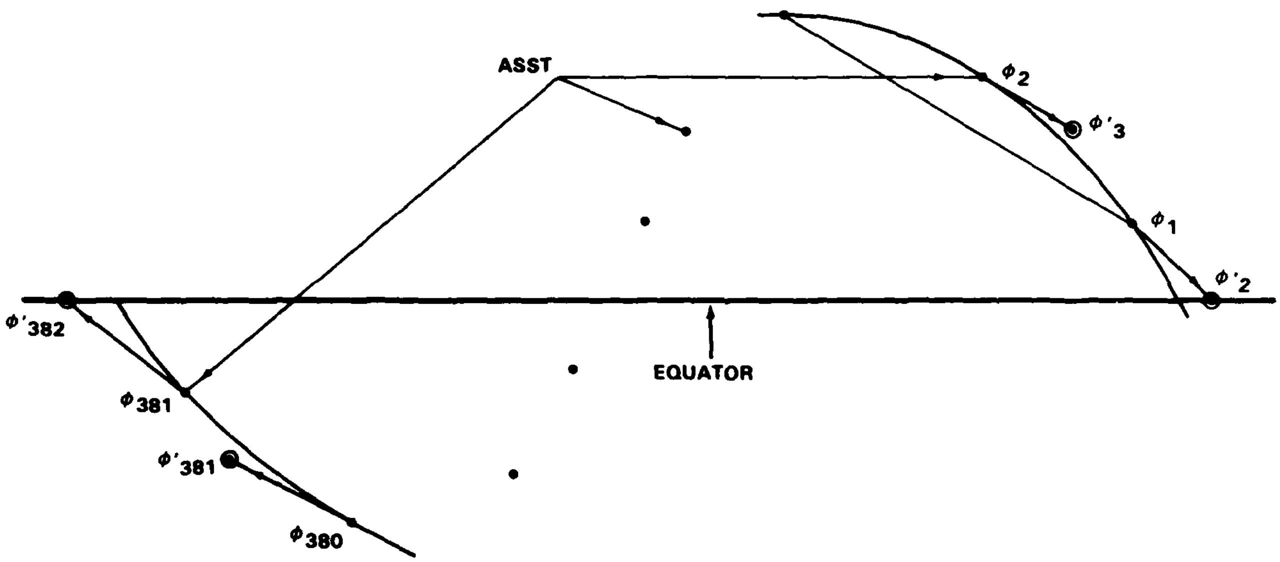

Figure 1. Construction of ESST from ASST

• Approximate SST points

◉ Exact points

(3) Now generate the (basic) SST

$$\lambda_1 = 360 - \lambda'_3, \phi_1 = -\phi'_3$$
$$\lambda_2 = 360, \ \phi_2 = 0$$
$$\lambda_j = \lambda'_j, \ \phi_j = \phi'_j \quad (j = 3, 4, \ldots, 381)$$
$$\lambda_{382} = \lambda'_{382}, \ \phi_{382} = 0$$
$$\lambda_{383} = 2\lambda'_{382} - \lambda'_{381}, \ \phi_{383} = -\phi'_{381},$$
$$\hat{\lambda} = 720 - \lambda_{382},$$

and

$$\Delta\tau = \hat{\tau}'/380$$

(4) Print all SST points (λ_j, ϕ_j) $j = 1,2,\ldots, 383$, $\hat{\lambda}$, and $\Delta\tau$ on the SST G Tape I as described in Section 4.

Note 2: The User's Guide and Program Listing are given in Appendix A.

Definition of 1° x 1° SST Grid System

A 1° x 1° SST grid system of the earth is defined by shifting the basic SST (see (3) above) one-degree-wise westward "parallel" to itself as shown in Figure 2. Accordingly, the grid points are defined by:

$$\left.\begin{aligned} \lambda_{jk} &= \lambda_j + 1 - k \ (+\ 360 \text{ if } < 0) \\ \phi_{jk} &= \phi_j \end{aligned}\right\} \begin{aligned} j &= 1,2,\ldots, 383 \\ k &= 1,2,\ldots, 360 \end{aligned}$$

Note 3: As can be seen in Figure 2, the SST grid system is not a unique coordinate system. Indeed, through every given point in the SST range, one finds two crossing SST (ordinate) lines and in the overlapping region around the equator even three. Nevertheless, since only points on shifted SSTs will be considered in the STT program of Section 5, a unique geographical orientation is possible with the help of the travel time $\Delta\tau$ between grid points on the SST.

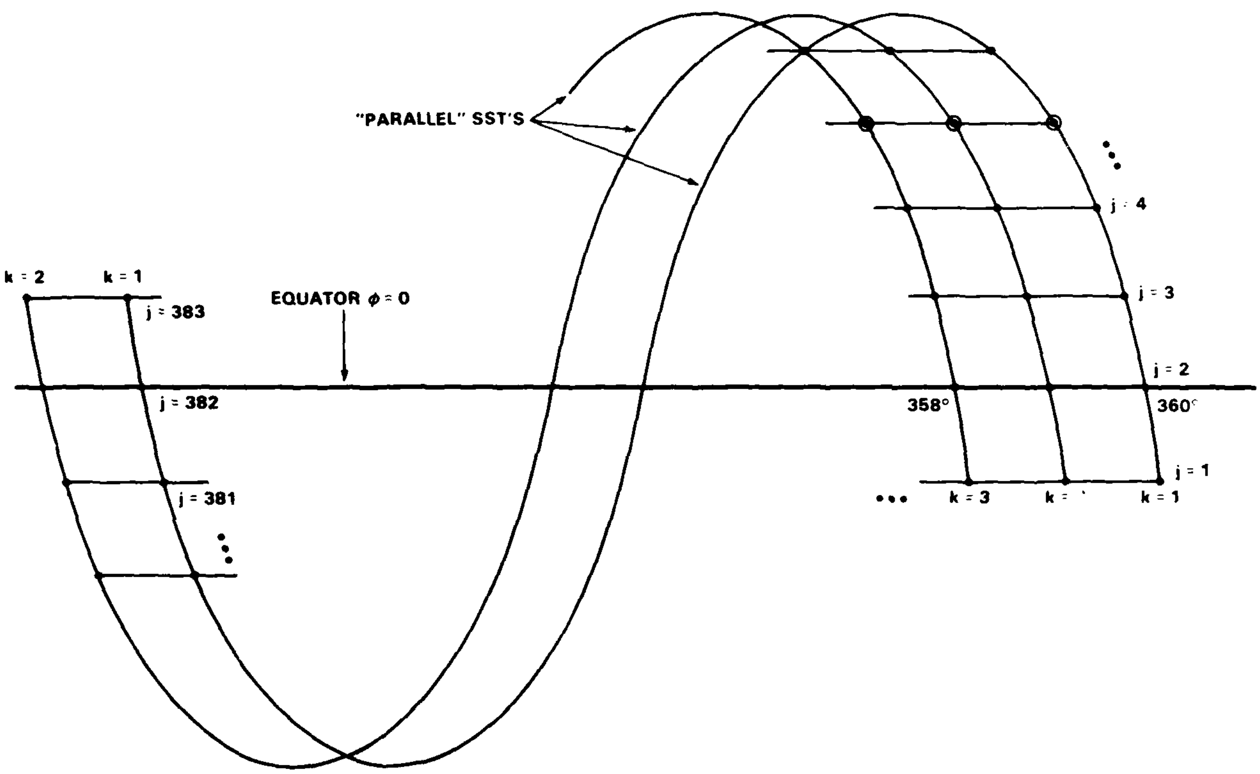

Figure 2. 1° x 1° SST Grid Scheme

◉ "Parallel" Points

3. NSWC STANDARD SATELLITE TRACK GEOCENTRIC TIDE DATA (SST GTD) PROGRAM

The NSWC (SST GTD) program interpolates at all SST grid points (Section 2) amplitudes and phases of any desired partial ocean tide by second-order ruled surfaces (linear in both east and north directions) using the NSWC GOTD tape described in Schwiderski and Szeto (1981). The interpolated values are modified by harmonic addition of the corresponding amplitudes and phases of the earth tide and of the earth dip in response to the ocean tidal load. These modifications are used in the form of simple Love and Accad-Pekeris approximations as explained in Schwiderski and Szeto (1981). Hence, the generated new harmonic constants on the $1° \times 1°$ SST grid system constitute amplitudes and phases of the total geocentric partial tide.

Note 1: No special effort is made to improve the accuracy of the oceanic tides in coastal waters. If higher accuracies are desired in such areas, instantaneous tidal computations should apply local refinements as suggested in Schwiderski (1981j) and Schwiderski and Szeto (1981).

A. Input Data

(1) (λ_j, ϕ_j) = *longitudes* (East, $0° \leq \lambda_j \leq 360°$) *and latitudes* (North, $-89° < \phi_j < +89°$) of j = 1, 2, 3 ..., 383 SST points generated by the SST program of Section 2 and printed, e.g., on the NSWC SST GTD Tape I described in Section 4 (Pole regions excluded !).

(2) $(\xi^i_{m,n}, \delta^i_{m,n})$ = ocean tide amplitudes (in m) and Greenwich phases (in deg) from GOTD 1981 tape, where m = 1,2, ... , 360 (longitude numbers) n = 1,2, ... , 168 (latitude number), and

(3) i = specified mode number $1 \leq i \leq 11$.

Note 2: $\xi^i_{m,n} = 9.999$, $\delta^i_{m,n} = 999.9$ on land

$\delta^i_{m,n} = 360° = 0°$ (phase jump)

(4) Earth tide parameters in GOTD Mode Order (see Schwiderski and Szeto 1981):

M_2	:	$i = 1,$	$\nu_1 = 2,$	$E_1 = 0.148\ 308$
S_2	:	$i = 2,$	$\nu_2 = 2,$	$E_2 = 0.069\ 059$
K_1	:	$i = 3,$	$\nu_3 = 1,$	$E_3 = 0.086\ 638$
O_1	:	$i = 4,$	$\nu_4 = 1,$	$E_4 = 0.061\ 551$
N_2	:	$i = 5,$	$\nu_5 = 2,$	$E_5 = 0.028\ 396$
P_1	:	$i = 6,$	$\nu_6 = 1,$	$E_6 = 0.028\ 668$
K_2	:	$i = 7,$	$\nu_7 = 2,$	$E_7 = 0.018\ 791$
Q_1	:	$i = 8,$	$\nu_8 = 1,$	$E_8 = 0.011\ 785$
Mf	:	$i = 9,$	$\nu_9 = 0,$	$E_9 = 0.025\ 546$
Mm	:	$i = 10,$	$\nu_{10} = 0,$	$E_{10} = 0.013\ 480$
Ssa	:	$i = 11,$	$\nu_{11} = 0,$	$E_{11} = 0.011\ 901$

B. Main Computation

(1) Transfer to core memory

(λ_j, ϕ_j) for $j = 1, 2, 3 \ldots 383$

Set $j = 1$ and $k = 1$

(2) Compute

$$\bar{\lambda}_j = (\lambda_j + 1.5 - k) \bmod 360, \ (0 \leq \bar{\lambda} \leq 360)$$

$$m = \mathrm{Int}\,[\bar{\lambda}_j] + 1,$$

$$\psi = m - \bar{\lambda}_j$$

$$n = \mathrm{Int}\,[90.5 - \phi_j] + 1,$$

$$\theta = \bar{\theta} = n - (90.5 - \phi_j)$$

If $n > 169$ (Antarctica!), set

$$\xi^i_{j,k} = \delta^i_{j,k} = 0$$

and go to (3) below.

If $n \not> 169$, transfer to core memory

$$(\xi^i_{m-1,\,n-1}, \delta^i_{m-1,\,n-1}); (\xi^i_{m,\,n-1}, \delta^i_{m,\,n-1})$$

$$(\xi^i_{m-1,\,n}, \delta^i_{m-1,\,n}), \qquad (\xi^i_{m,n}, \delta^i_{m,n}),$$

where

$m - 1 = 0 \rightarrow 360$ and for $n = 169$

$$\xi^i_{m-1,169} = \xi^i_{m,169} = 9.999$$

$$\delta^i_{m-1,169} = \delta^i_{m,169} = 999.9$$

Check for land points and replace:

(a) if $\xi^i_{m,n-1} = 9.999$, replace $\theta \rightarrow 0$

(b) if $\xi^i_{m,n} = 9.999$, replace $\theta \rightarrow 1$

(c) if (a) and (b) hold, replace $\psi \rightarrow 1$

(d) if $\xi^i_{m-1,n-1} = 9.999$, replace $\bar{\theta} \rightarrow 0$

(e) if $\xi^i_{m-1,n} = 9.999$, replace $\bar{\theta} \rightarrow 1$

(f) if (d) and (e) hold, replace $\psi \rightarrow 0$

If (c) and (f) hold (Land!), set

$$\xi^i_{n,k} = \delta^i_{j,k} = 0$$

and go to (3) below, otherwise interpolate $\xi_{j,k}$ on the ruled second-order surface in ψ and θ

$$\xi_{j,k} = (1-\psi)\,[\theta\xi^i_{m,n-1} + (1-\theta)\,\xi^i_{m,n}] + \psi\,[\bar{\theta}\,\xi^i_{m-1,n-1} + (1-\bar{\theta})\,\xi^i_{m-1,n}]. \qquad (*)$$

Test for 360° phase jumps and replace

$$\text{if } \delta^i_{m,n-1} - \delta^i_{m,n} \begin{cases} > 180, \text{ replace } \delta^i_{m,n-1} \rightarrow \delta^i_{m,n-1} - 360 \\ < -180, \text{ replace } \delta^i_{m,n-1} \rightarrow \delta^i_{m,n-1} + 360 \end{cases}$$

$$\text{if } \delta^i_{m-1,n-1} - \delta^i_{m,n} \begin{cases} > 180, \text{ replace } \delta^i_{m-1,n-1} \rightarrow \delta^i_{m-1,n-1} - 360 \\ < -180, \text{ replace } \delta^i_{m-1,n-1} \rightarrow \delta^i_{m-1,n-1} + 360, \end{cases}$$

$$\text{if } \delta^i_{m-1,n} - \delta^i_{m,n} \begin{cases} > 180, \text{ replace } \delta^i_{m-1,n} \rightarrow \delta^i_{m-1,n} - 360 \\ < -180, \text{ replace } \delta^i_{m-1,n} \rightarrow \delta^i_{m-1,n} + 360 \end{cases}$$

Use adjusted δ's to interpolate $\delta_{j,k}$ by formula (*) with ξ replaced by δ. Now compute and replace (ocean loading effect, see Schwiderski and Szeto 1981)

$$\xi_{j,k} \rightarrow 0.9333\, \xi_{j,k}$$

Compute earth tide amplitude function

$$\bar{E}_j = \begin{cases} E_i \cos^2 \phi_j & \text{for } \nu_i = 2 \\ E_i \sin 2\phi_j & \text{for } \nu_i = 1 \\ \frac{1}{2} E_i (3\cos^2 \phi_j - 2) & \text{for } \nu_i = 0 \end{cases}$$

Finally, compute geocentric harmonic constants by harmonic addition (cos and sin arguments in degrees).

$$\xi^i_{j,k} = \left\{(\xi_{j,k})^2 + (\bar{E}_j)^2 + 2\bar{E}_j\, \xi_{j,k} \cos\left[\delta_{j,k} + \nu_i (\lambda_j - k + 1)\right]\right\}^{1/2}$$

$$\delta^i_{j,k} = \tan^{-1} \frac{\xi_{j,k} \sin \delta_{j,k} - \bar{E}_j \sin\left[\nu_i (\lambda_j - k + 1)\right]}{\xi_{j,k} \cos \delta_{j,k} + \bar{E}_j \cos\left[\nu_i (\lambda_j - k + 1)\right]}$$

where $0 \leqslant \delta \leqslant 2\pi$ in radians.

(3) If $j < 383$, replace $j \rightarrow j + 1$ and repeat (2) above.
If $j \not< 383$, print all data $(\xi^i_{j,k}, \delta^i_{j,k})$
$j = 1, 2, \ldots, 383$ and k on the magnetic tape SST GTD I, II, or III depending on the mode i as described in Section 4.
If $k < 360$, replace $k \rightarrow k + 1, j \rightarrow 1$, and repeat (2) above.
If $k \not> 360$, stop program.

Note 3: The User's Guide and Program Listing of this program are presented in Appendix B. Evidently, by applying this program for all mode numbers i = 1, 2, 3, ... , 11, one generates the SST GTD Tapes I, II, and III described in Section 4.

4. NSWC STANDARD SATELLITE TRACK GEOCENTRIC TIDE DATA (SST GTD) TAPES I, II, AND III

The NSWC SST GTD Tapes I, II, and III contain the geocentric (including earth tide and loading effects) harmonic tidal constants; i.e., amplitudes and phases

$$\left(\xi^i_{j,k} \cdot \delta^i_{j,k}\right) \begin{cases} i = 1, 2, \ldots, 11 \\ j = 1,2, \ldots, 383 \\ k = 1,2, \ldots, 360 \end{cases} \qquad (*)$$

generated by the SST GTD program described in Section 3. The data are defined on a 1° x 1° SST grid system, which is defined in Section 2 on the basis of an SST specified by the longitudes (East, in deg) and latitudes (North, in deg), respectively,

$$(\lambda_j, \phi_j) \quad (j = 1,2, \ldots, 383) \qquad (**)$$

which are also listed on SST GTD Tape I.

Computationally, the tidal data (*) are arranged by modes i(= 1, 2, ... , 11) on the three magnetic tapes in the order shown in Table 1 below.

Table 1: Mode Arrangement on SST GTD Tapes

SST GTD I	$i = 1 : M_2$	$i = 2 : S_2$	$i = 3 : K_1$	$i = 4 : O_1$	SST
SST GTD II	$i = 5 : N_2$	$i = 6 : P_1$	$i = 7 : K_2$	$i = 8 : Q_1$	–
SST GTD III	$i = 9$: Mf	$i = 10$: Mm	$i = 11$: Ssa	–	–

In each mode i(= 1, 2, ... ,11), the tidal constants (*) are arranged by SST-numbers k (= 1, 2, ... , 360) in consecutive pairs of blocks with each block containing 384 words j (= 1,2, ... , 384). The first 383 words (in Format F10.8) in the first block are amplitudes $\xi^i_{j,k}$ (in m) and in the second block Greenwich phases $\delta^i_{j,k}$ (in rad). The last word (j = 384) in each block (in Formate I 10) gives the SST number k (= 1,2, ... , 360) of the block pair.

As shown in Table 1, the SST GTD Tape I contains two additional (final) blocks of 384 words j(= 1, 2, ... , 384) in Format F 10.6. The first 383 words in the first block represent the SST latitudes ϕ_j (in deg) and in the second block the SST longitudes λ_j (in deg). The last word j = 384 in the first block gives the SST spacing time $\Delta\tau$ (in sec), and in the second block the periodic longitude shift $\hat{\lambda}$ of the SST (in deg.).

All data have been blockwise generated on the corresponding magnetic tapes (Table 1) by the BUFFER-OUT Statement on the CDC 6700 computer. These tapes have the following standard properties: 7 track, BDC form, even parity, 556 bpi, and unlabeled.

Note: On land (see Schwiderski 1978c) all tide data (*) are set to zero (see Section 3), i.e.

$$\xi^{i}_{j,k} = \delta^{i}_{j,k} = 0 \text{ for land.}$$

5. NSWC SATELLITE TRACK TIDE (STT) PROGRAM

The NSWC STT program uses the SST GTD Tapes I, II, and III described in Sections 3 and 4 to compute efficiently instantaneous geocentric tides at equidistant points and instances along "constrained satellite (say, SEASAT) tracks CST's" that are essentially parallel-displaced segments of the basic SST defined in Section 2 (see Figures 1, 2, and 3). The computed geocentric tides include the ocean tides superposed with the corresponding earth tides and earth dips in response to the oceanic tidal loads (see Schwiderski and Szeto 1981). When all leading tidal modes (M_2, S_2, K_1, O_1, N_2, P_1, K_2, Q_1, Mf, Mm, and Ssa; see Table 2) are included, the resulting instantaneous tidal elevations carry a 10-cm accuracy anywhere over open ocean areas (see Schwiderski 1978a, b, 1979a–e, 1980, 1981a–j, and 1982a–d). This accuracy diminishes somewhat in coastal waters where special improved computations are suggested in Schwiderski (1981j) and Schwiderski and Szeto (1981).

Definition of Constrained Satellite Tracks (CST)

A CST is a uniformly spaced (at least two points) segment of a satellite ground track, which (see Figure 3):

(a) Is ***almost parallel*** (congruent) to the basic SST of the SST GTD Tapes I, II, and III defined in Sections 2, 3, and 4.

(b) Is ***gridwise continuous***, i.e., it is without gaps in equidistant spacing points.

(c) Lies ***almost entirely between*** the track's two consecutive ***ascending nodal points*** on the equator.

(d) Lies ***almost entirely over*** the global ***ocean area*** specified by non-zero tidal constants listed on the SST GTD Tapes I, II, and III of Section 4.

Note 1: If condition (a) is violated, say, by more than 0.5° along the given CST when shifted to coincide with the SST, then a new appropriate SST and corresponding, SST GTD tapes ***must*** be prepared (see Sections 2, 3, and 4).

Note 2: Satellite tracks that are not gridwise continuous, cross the equator, say, by more than 5 sec and/or pass over land areas ***must*** be broken up into separate segments of CSTs to fulfill the conditions (b, c, and d) above.

A. Input Data:

(1) y = year $\geq$ 1975 (fixed for one run!)
(2) d = day of year y (d = 1 for January 1st, also fixed for one run!)

(3) t_1 = initial time (in sec) of first CST point (λ_1, ϕ_1) relative to Greenwich midnight of day d (universal time)

(4) Δt = constant time step (in sec) along CST

(5) N (>1) = total number of CST points

(6) (λ_n, ϕ_n) = longitudes (East) and latitudes of first two (n = 1, 2) CST points (in deg.)

(7) (λ_a, λ_b) = equator-crossing longitudes (in deg.) corresponding to the two consecutive ascending nodes of the track containing the CST

(8) (t_a, t_b) = equator-crossing times (in sec) relative to Greenwich midnight of day d, (d + 1), or (d − 1) for t_a *belonging to* λ_a *and* of day d, (d − 1), or (d + 1) for t_b belonging to λ_b

(9) $(\xi^i_{j,k}, \delta^i_{j,k})$ = geocentric tidal amplitudes (in m) and Greenwich phases (in rad) from SST GTD Tapes I, II, and III, where

i = 1, 2, ... , I (≤ 11) = mode numbers

j = 1,2, ... , 383 = SST spacing points

k = 1,2, ... , 360 = SST ordinate lines (see Figures 2 and 3)

(10) I = total number of tidal modes (1 ≤ I ≤ 11) to be superposed

(11) $\Delta\tau$ = SST time step from SST GTD Tape I (in sec)

(12) $\hat{\lambda}$ = period longitude shift (in deg) of SST from SST GTD Tape I

Note 3: The CST data (3, 4, 5, and 6) ***must*** satisfy the CST definition above, necessary splits will be requested!

Note 4: For the equator-crossing longitudes (λ_a, λ_b) and the corresponding times t_a and t_b error bounds of less than 0.1° and 1.0 sec, respectively, are strongly recommended. Errors of more than 0.4° and 4.0 sec will be ***rejected*** for corrections (see B(3) and (4) below).

Note 5: The tidal data

$\xi^i_{j,k} = \delta^i_{j,k} = 0$ signal land, and

$\delta^i_{j,k} = 2\pi = 0$ a phase jump.

Table 2. Constants of Major Tidal Modes

Tidal Mode	*K* (m)	σ (10^{-4}/sec)	χ (deg)
	Semidiurnal Species		
M_2 = Principal Lunar	0.242 334	1.405 19	$2h_0 - 2s_0$
S_2 = Principal Solar	0.112 841	1.454 44	0
N_2 = Elliptical Lunar	0.046 398	1.378 80	$2h_0 - 3s_0 + p_0$
K_2 = Declination Luni-Solar	0.030 704	1.458 42	$2h_0$
	Diurnal Species		
K_1 = Declination Luni-Solar	0.141 565	0.729 21	$h_0 + 90$
O_1 = Principal Lunar	0.100 574	0.675 98	$h_0 - 2s_0 - 90$
P_1 = Principal Solar	0.046 843	0.725 23	$-h_0 - 90$
Q_1 = Elliptical Lunar	0.019 256	0.649 59	$h_0 - 3s_0 + p_0 - 90$
	Long-Period Species		
Mf = Fortnightly Lunar	0.041 742	0.053 234	$2s_0$
Mm = Monthly Lunar	0.022 026	0.026 392	$s_0 - p_0$
Ssa = Semiannual Solar	0.019 446	0.003 9821	$2h_0$

K = amplitude of the partial tide
σ = frequency of the partial tide
χ = astronomical argument of the partial tide
(h_0, s_0, p_0) = mean longitudes of sun, moon, and lunar perigee at Greenwich midnight
$h_0 = 279.696\,68 + 36\,000.\,768\,925\,485T + 3.03 \cdot 10^{-4} T^2$
$s_0 = 270.434\,358 + 481\,267.883\,141\,37T - 0.001\,133T^2 + 1.9 \cdot 10^{-6}\,T^3$
$p_0 = 334.329\,653 + 4\,069.034\,032\,957\,5T - 0.010\,325T^2 - 1.2 \cdot 10^{-5}\,T^3$

where

$T = [27\,392.500\,528 + 1.000\,000\,035\,6D]/36\,525$
$D = d + 365(y - 1975) + \mathrm{Int}\,[(y - 1973)/4]$
d = day number of year (d = 1 for January 1)
$y \geq 1975$ = year number,

and

Int [x] = integral part of x

B. Computation of SST Grid Brackets and Other Constants for CST

In the following preliminary computations, the given CST will be bracketed between two consecutive SST grid ordinates k and (k + 1) as shown in Figure 3. Subsequently, time and space constants will be computed, which are needed in the following main computations.

(1) Transfer to core memory the CST data

y, d, t_1, Δt, N, t_a, t_b, λ_a, λ_b, (λ_1, ϕ_1), (λ_2, ϕ_2), and from the SST GTD Tape I the SST data

$$\Delta\tau \text{ and } \hat{\lambda}.$$

(2) Compute and adjust day count

$$\lambda' = 360 - \lambda_b + \lambda_a \ (+\,360 \text{ if} < 360),$$

$$\hat{t} = t_b - t_a \ (+\,86400 \text{ if} < 0),$$

$$\hat{\tau} = 380\,\Delta\tau, \tau_1 = t_1 - t_a.$$

If $\tau_1 > 3\hat{t}$, replace

$$\tau_1 \to \tau_1 - 86400, t_1 \to t_1 - 86400, d \to d + 1.$$

If $\tau_1 < -\,3\hat{t}$, replace

$$\tau_1 \to \tau_1 + 86400, t_1 \to t_1 + 86400, d \to d - 1.$$

(3) Compute and check

$$\tau_N = \tau_1 + (N - 1)\,\Delta t.$$

If $\tau_1 < -\,\Delta\tau/2$ and/or $\tau_N - \hat{\tau} > \Delta\tau/2$, stop and print: Check Track Data! Otherwise compute and replace

$$\Delta t \to \Delta t\,\hat{\tau}/\hat{t}, \quad t_\epsilon = t_a,$$

$$\tau_1 \to \tau_1\,\hat{\tau}/\hat{t}$$

$$\lambda_\epsilon = \lambda_a + \frac{1}{2}(\lambda' - \hat{\lambda}) \begin{cases} +\,360 \text{ if } < 0 \\ -\,360 \text{ if } > 360 \\ +\,0 \text{ otherwise.} \end{cases}$$

(4) If $|\tau_1| < \Delta\tau$ compute

$$\phi = \phi_1/(\phi_2 - \phi_1),$$

$$\Delta\lambda_1 = \lambda_1 - \lambda_2 \ (+\,360 \text{ if } < 0),$$

$$\Delta\lambda = \lambda_\epsilon - \lambda_1 \ (+\,360 \text{ if } < -10),$$

$$\Delta\lambda' = \phi\Delta\lambda_1,$$

$$\tau_i' = \phi\Delta t.$$

If $|\tau_1 - \tau_i'| > 0.4\ \Delta\tau$

and/or

$$|\Delta\lambda - \Delta\lambda'| > 0.4,$$

stop and print: Check Track Data! Otherwise replace

$$t_\epsilon \rightarrow t_\epsilon + \tau_1 - \tau_i', \tau_1 \rightarrow \tau_i',$$

$$\lambda_\epsilon \rightarrow \lambda_1 + \Delta\lambda' \begin{cases} +\,360 \text{ if} < 0 \\ -\,360 \text{ if} > 360 \\ +\,0 \text{ otherwise.} \end{cases}$$

(5) Compute the CST bracket data (see Figure 3)

$$k = \text{Int}\,[361 - \lambda_\epsilon], \lambda = (361 - \lambda_\epsilon) - k.$$

Replace

$$k = 361 \rightarrow 1.$$

Compute and replace

$$J = \text{Int}\,[2 + \tau_1/\Delta\tau],$$

$$M = \text{Int}\,[4 - J + \tau_N/\Delta\tau],$$

$$\tau_1 \rightarrow \tau_1 - (J - 2)\Delta\tau$$

(6) Compute the constants

$$\Delta\tilde{\tau} = 1/\Delta\tau,\ \tilde{\tau}_1 = \Delta\tilde{\tau}/2,\ \tilde{\tau}_2 = \tilde{\tau}_1\ \Delta\tilde{\tau}, \tilde{\tau}_3 = \tilde{\tau}_2\ \Delta\tilde{\tau}$$

With the tidal parameters h_0, s_0, p_0, and (σ_i, χ_i; i = 1, 2, ..., 11) listed in Tables 1 and 2 computed for i = 1, 2, ... ,11.

$$\bar{\sigma}_i = \sigma_i\ \Delta\tau\ , \bar{\chi}_i = \sigma_i t_\epsilon - 2\ \bar{\sigma}_i + \pi\chi_i/180$$

Keep the constants I, J, k, M, N, λ, Δt, Δτ, $\Delta\tilde{\tau}$, τ_1, $\tilde{\tau}_1, \tilde{\tau}_2, \tilde{\tau}_3$, and ($\bar{\sigma}_i$, $\bar{\chi}_i$; i = 1, 2, ... ,11) for the main computations.

C. First Rough Interpolation

In this first step tidal amplitudes and phases are mode-wise linearly interpolated at the SST-spacing points on the CST using the data along the neighboring SST ordinate lines k and (k + 1) as shown in Figure 3. Subsequently, instantaneous geocentric tides $\bar{\zeta}_m$ are computed from the interpolated harmonic constants, which are automatically mode-wise superposed.

(1) Set: i = 1 and $\bar{\zeta}_m$ = 0 for m = 1, 2, ... , M

(2) Transfer to core memory the tidal constants

$(\xi^i_{j,k}, \delta^i_{j,k})$ and $(\xi^i_{j,k+1}, \delta^i_{j,k+1})$

for j = 1,2, ... , 383 and i and k fixed (k + 1 = 361 → 1!)

Set

j = J, m = 1

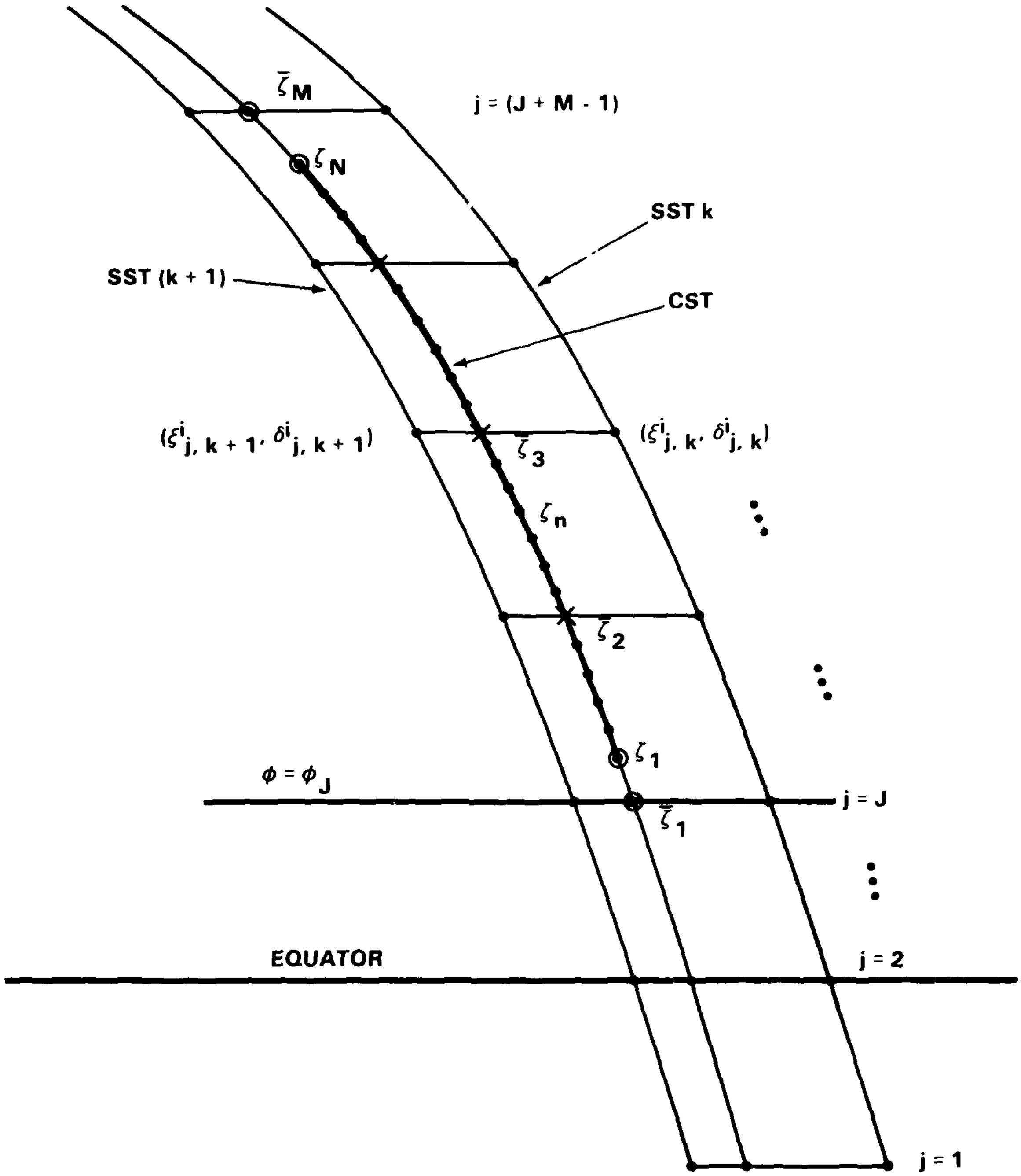

Figure 3. Scheme of Tide Interpolation

Ⓧ, x = SST Spacing Points on CST

⊙ • = CST Spacing Points on CST

(3) Check for land points and define (λ_1, λ_2) as follows

$$\text{For } \xi^i_{j,k} \begin{cases} > 0 \text{ set } \lambda_2 = \lambda \\ \not> 0 \text{ set } \lambda_2 = 1 \end{cases}$$

$$\text{For } \xi^i_{j,k+1} \begin{cases} > 0 \text{ set } \lambda_1 = 1 - \lambda \\ \not> 0 \text{ set } \lambda_1 = 1 \end{cases}$$

Now interpolate linearly

$$\xi_m = \lambda_1 \, \xi^i_{j,k} + \lambda_2 \, \xi^i_{j,k+1} \qquad (*)$$

check for 2π-phase jumps and replace δ's for

$$\delta^i_{j,k} - \delta^i_{j,k+1} \begin{cases} > \pi \text{ replace } \delta^i_{j,k+1} \rightarrow \delta^i_{j,k+1} + 2\pi \\ < -\pi \text{ replace } \delta^i_{j,k} \rightarrow \delta^i_{j,k} + 2\pi \end{cases}$$

Use adjusted δ's to compute δ_m by *formula* (*) with $\xi \rightarrow \delta$

Now compute the superposed *instantaneous* tide

$$\bar{\zeta}_m \rightarrow \bar{\zeta}_m + \xi_m \cos(\bar{\sigma}_i \, j + \bar{\chi}_i - \delta_m)$$

If $m < M$, replace $m \rightarrow m + 1$, $j \rightarrow j + 1$, and repeat (3) above. If $(m \nless M)$, go to (4) below.

(4) If $i < I$, replace $i \rightarrow i + 1$ and repeat (2) above.

If $(i \nless I)$, follow D below, but keep the constants M, N, Δt, $\Delta\tau$, $\Delta\tilde{\tau}$, τ_1, $\tilde{\tau}_1$, $\tilde{\tau}_2$, $\tilde{\tau}_3$, and $\bar{\zeta}_m$ (m = 1,2, ... , m).

D. Second Refined Interpolation

The finally desired instantaneous geocentric tides ζ_n $(n = 1,2, \dots, N)$ at the given CST spacing points are generally computed by a "cubic-parabolic spline" interpolation to achieve a smooth tangent variation along the ζ_n. In order to compute the tide ζ_n, say, between the SST - spaced data $\bar{\zeta}_2$ and $\bar{\zeta}_3$ (see C and Figure 3) a "cubic" polynomial is forced through $\bar{\zeta}_2$ and $\bar{\zeta}_3$ with the corresponding "parabolic" slopes

$$\bar{\xi}'_m = (\bar{\zeta}_{m+1} - \bar{\zeta}_{m-1})/\tau_1 \text{ for } m = 2, \text{ and } 3$$

Naturally, for shorter CSTs; e.g., between land areas (signaled by $\bar{\zeta} = 0$ data) only ordinary parabolic or linear interpolation is used. In detail, the following tests must be made, which lead to the different interpolation cases 1, 2, 3, 4, and (subsequently) 5.

(1) If $M > 2$ *and* $\bar{\zeta}_2 \neq 0$, *and*

(1.1) $\bar{\zeta}_3 \neq 0$, *and*

(1.1.1) $\bar{\zeta}_1 \neq 0$, set

$\tau = \tau_1$, $m = 1$, $n = 1$, and go to case 3

(1.1.2) ($\bar{\zeta}_1 = 0$), set

$\tau = \tau_1 - \Delta\tau$, $m = 2$, $n = 1$, *and*

(1.1.2.1) for $M > 3$ *and* $\bar{\zeta}_4 \neq 0$, go to case 3

(1.1.2.2) otherwise go to case 2

(1.2) ($\bar{\zeta}_3 = 0$), *and*

(1.2.1) $\bar{\zeta}_1 \neq 0$, set

$\tau = \tau_1$, $m = 1$, $n = 1$ and go to case 2

(1.2.2) ($\bar{\zeta}_1 = 0$), go to case (1)

(2) If (1) fails *and*

(2.1) $M \ngtr 2$, $\bar{\zeta}_2 \neq 0$, *and* $\bar{\zeta}_1 \neq 0$, set $\tau = \tau_1$, $m = 1$, $n = 1$, and go to case 2

(2.2) otherwise go to case 1

Now compute the interpolutions

Case 1. Constant interpolation for one oceanic datum $\bar{\zeta}_1 \neq 0$ or $\bar{\zeta}_2 \neq 0$

Compute

$$\zeta_n = \bar{\zeta}_1 + \bar{\zeta}_2 \text{ for } n = 1, 2, \ldots, N, \text{ and go to E}$$

Case 2: Linear interpolation for two oceanic data $\bar{\zeta}_m \neq 0$ and $\bar{\zeta}_{m+1} \neq 0$

With $a = \Delta\tilde{\tau}(\bar{\zeta}_{m+1} - \bar{\zeta}_m)$, $b = a\,\Delta t$, compute

$$\zeta_1 = \bar{\zeta}_m + a\,\tau, \text{ for } n = 1$$

$$\zeta_n = \zeta_{n-1} + b, \text{ for } n = 2, 3, \ldots, N, \text{ and go to E}$$

Case 3: Parabolic interpolation for three oceanic data $\bar{\zeta}_m \neq 0$, $\bar{\zeta}_{m+1} \neq 0$, and $\bar{\zeta}_{m+2} \neq 0$

(a) Compute:

$a = \tilde{\tau}_1 (-3\,\bar{\zeta}_m + 4\,\bar{\zeta}_{m+1} - \bar{\zeta}_{m+2})$, $b = \tilde{\tau}_2 (\bar{\zeta}_m - 2\,\bar{\zeta}_{m+1} + \bar{\zeta}_{m+2})$, and go for

$M < m + 3$, or $\bar{\zeta}_{m+3} = 0$ to (b), otherwise go to (c)

(b) Compute

$$\zeta_n = (b\tau + a)\,\tau + \bar{\zeta}_m$$

If $n < N$, replace $n \rightarrow n + 1$, $\tau \rightarrow \tau + \Delta t$, and repeat (b).

If $(n \nless N)$, go to E.

(c) Compute

$$\zeta_n = (b\tau + a)\,\tau + \bar{\zeta}_m$$

Replace $n \rightarrow n + 1$ and $\tau \rightarrow \tau + \Delta t$

If $\tau < \Delta\tau$, repeat (c)

If $(\tau \nless \Delta\tau)$, replace $\tau \rightarrow \tau - \Delta\tau$, $m \rightarrow m + 1$, and go to Case 4 below.

Case 4: Cubic-parabolic interpolation for four oceanic data, $\bar{\zeta}_{m-1} \neq 0$, $\bar{\zeta}_m \neq 0$, $\bar{\zeta}_{m+1} \neq 0$, and $\zeta_{m+2} \neq 0$:

(a) Compute

$a = \tilde{\tau}_1 (\bar{\zeta}_{m+1} - \bar{\zeta}_{m-1})$, $b = \tilde{\tau}_2 (2\,\bar{\zeta}_{m-1} - 5\,\bar{\zeta}_m + 4\,\bar{\zeta}_{m+1} - \bar{\zeta}_{m+2})$

$c = \tilde{\tau}_3 (\bar{\zeta}_{m+2} - 3\,\bar{\zeta}_{m+1} + 3\,\bar{\zeta}_m - \bar{\zeta}_{m-1})$, and go to (b) below

(b) Compute

$\zeta_n = [(c\tau + b)\tau + a)]\ \tau + \bar{\zeta}_m$

Replace $n \rightarrow n + 1$ and $\tau \rightarrow \tau + \Delta t$

If $\tau < \Delta\tau$, repeat (b)

If $(\tau \nless \Delta\tau)$, replace $\tau \rightarrow \tau - \Delta\tau$, and $m \rightarrow m + 1$, ***and*** if $M < m + 2$, ***or*** $\bar{\zeta}_{m+2} = 0$, go to Case 5, otherwise repeat (a) above.

Case 5: Parabolic end-point interpolation for three oceanic data $\bar{\zeta}_{m-1} \neq 0$, $\bar{\zeta}_m \neq 0$, and $\bar{\zeta}_{m+1} \neq 0$:

(a) Compute

$a = \tilde{\tau}_1\ (\bar{\zeta}_m - \bar{\zeta}_{m-1})$, $b = \tilde{\tau}_2(\bar{\zeta}_{m+1} - 2\,\bar{\zeta}_m + \bar{\zeta}_{m-1})$, and go to (b) below

(b) Compute

$\zeta_n = (b\tau + a)\,\tau + \bar{\zeta}_m$

If $n < N$, replace $n \rightarrow n + 1$, $\tau \rightarrow \tau + \Delta t$ and repeat (b)

If $(n \nless N)$, go to E

E. Output Data

List and/or print on tape all tidal data

$$\zeta_n\ :\ n = 1, 2, \ldots, N$$

as specifically requested.

Note 5: The User's Guide and Program Listing of this program are given in Appendix C.

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APPENDIX A

SST PROGRAM USER'S GUIDE AND PROGRAM LISTING

APPENDIX A

1. SST PROGRAM USER'S GUIDE

The Standard Satellite Track (SST) program generates from a given Approximate Standard Satellite Track (ASST) (see Section 2, Part A) an Exact Standard Satellite Track (ESST) that is used by the SSTGTD (see Section 3) program.

The following listing shows the SST program written in CDC Fortran Extended for the CDC 6700 computer under the SCOPE 3.4 operating system.

Input to the SST program consist of the ASST file attached to TAPE1 and a data card containing the orbital period in seconds with E20.9 format. The computed ESST is written onto a file called TAPE2. This ESST will be called the SST.

2. SST PROGRAM LISTING

PROGRAM SST 73/74 OPT=1 FTN 4.6+433 01/14/83 17.14.35 PAGE 1

```
      PROGRAM SST(INPUT,OUTPUT
     * ,TAPE1, TAPE2)
C     ..
C     ..SST(STANDARD SATELLITE TRACK) PROGRAM
C AUTHOR
C     L. T. SZETO
C LANGUAGE
C     CDC FORTRAN EXTENDED
C     ..
      REAL LONG(384), LAT(384)
      REAL LATP(384), LONGP(384)
C     ..READ IN ASST(APPROXIMATE STANDARD TRACK) DATA
      READ(1) (( LAT(I), LONG(I)),I=1,381)
C     CHECK MINIMUM APPROXIMATE CONDITIONTO AVOID
C     SIGNIFICANT LOSSES IN ACCURACY.
      CALL CHECK( LAT)
      READ 5,PERIOD
 5    FORMAT(E20.9)
      SPACIN= PERIOD/380.
      DL1= LONG(1)- LONG(2)
      IF(DL1.LT.O.) DL1=DL1+360.
      DP1= LAT(2)- LAT(1)
      DL= LONG(380)- LONG(381)
      IF( DL.LT.O.) DL=DL+360.
      DP= LAT(381)- LAT(380)
      DT1= SPACIN*LAT(1)/ DP1
      DT=  SPACIN*LAT(381)/ DP
      THP= PERIOD- ( DT- DT1)
      DTT= ( DT- DT1)/380.
      V= SQRT( DL1*DL1+ DP1*DP1)/ SPACIN
      RL=360.- LONG(1)- LAT(1)*DL1/ DP1
      RRL= RL+ LONG(381)+ LAT(381)*DL / DP
      LONGP(382)= AMOD( RRL,360.)
C     ..
C     GENERATE THE BASIC SST
      DO 300 J=2,380
C         JP1=3,381
          DT1= DT1+ DTT
          JM1=J-1
          JP1=J+1
C         JP1=3,381
          DL= LONG(JM1)- LONG(JP1)
          IF(DL.LT.O.) DL=DL+360.
          DP= LAT(JP1)- LAT(JM1)
          S= V*DT1/ SQRT( DL*DL+ DP*DP)
          LONGP(JP1)= LONG(J)+ S*DL+ RL
          LONGP(JP1)= AMOD( LONGP(JP1),360.)
          LATP(JP1)= LAT(J)- S*DP
  300     CONTINUE
C     ENDDO
      LONG(1)= 360.- LONGP(3)
      LONG(2)= 360.
      LAT(1)= -LATP(3)
      LAT(2)=O.
      LONG(382)= LONGP(382)
      LONG(383)= LONGP(382)*2.- LONGP(381)
      LAT(382)=O.
```

```
                 LAT(383)=-LATP(381)
                 DO 500 J=3,381
                      LONG(J)= LONGP(J)
                      LAT(J)= LATP(J)
           500        CONTINUE
          C      ENDDO
          C      ..
          C      LAT(384)=SST SPACING TIME IN SECONDS
                 LAT (384)= THP/380.
          C      ..LONG(384)=PERIODIC LONGITUDE SHIFT OF THF THE SST IN DEGREES
                 LONG(384)=720.-LONG(382)
                 WRITE(2) (LAT(I),I=1,384)
                 WRITE(2)(LONG(I),I=1,384)
                 END
```

```
      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE     REFERENCES
10222  SST               1

VARIABLES     SN  TYPE             RELOCATION
10435  DL         REAL                         REFS      2*24       32     2*43     2*45       46
                                            DEFINED        23       24       42       43
10433  DL1        REAL                         REFS      2*21     2*30       31  DEFINED       20       21
10436  DP         REAL                         REFS        27       32     2*45       48  DEFINED       25       44
10434  DP1        REAL                         REFS        26     2*30       31  DEFINED       22
10440  DT         REAL                         REFS        28       29  DEFINED       27
10442  DTT        REAL                         REFS        38  DEFINED       29
10437  DT1        REAL                         REFS        28       29       38       45  DEFINED       26       38
10430  I          INTEGER                      REFS      2*13       69       70  DEFINED       13       69       70
10446  J          INTEGER                      REFS        39       40       46       48     2*60     2*61
                                            DEFINED        36       59
10447  JM1        INTEGER                      REFS        42       44  DEFINED       39
10450  JP1        INTEGER                      REFS        42       44       46     2*47       48
                                            DEFINED        40
11252  LAT        REAL         ARRAY           REFS        10       16     2*22     2*25       26       27       31
                                                 32      2*44       48       69  DEFINED       13       53       54
                                                 57        58       61       66
12052  LATP       REAL         ARRAY           REFS        11       53       58       61  DEFINED       48
10452  LONG       REAL         ARRAY           REFS        10     2*20     2*23       31       32     2*42       46
                                                 68        70  DEFINED       13       51       52       55       56
                                                 60        68
12652  LONGP      REAL         ARRAY           REFS        11       47       51       55     2*56       60
                                            DEFINED        33       46       47
10431  PERIOD     REAL                         REFS        19       28  DEFINED       17
10444  RL         REAL                         REFS        32       46  DEFINED       31
10445  RRL        REAL                         REFS        33  DEFINED       32
10451  S          REAL                         REFS        46       48  DEFINED       45
10432  SPACIN     REAL                         REFS        26       27       30  DEFINED       19
10441  THP        REAL                         REFS        66  DEFINED       28
10443  V          REAL                         REFS        45  DEFINED       30
```

```
         PROGRAM SST        73/74   OPT=1                          FTN 4.6+433        01/14/83  17.14.35        PAGE      3

FILE NAMES        MODE
   0  INPUT      FMT                     READS        17
2043  OUTPUT
4106  TAPE1      UNFMT                   READS        13
6151  TAPE2      UNFMT                  WRITES        69         70

EXTERNALS          TYPE    ARGS        REFERENCES
       CHECK                 1             16
       SQRT      REAL        1 LIBRARY     30         45

INLINE FUNCTIONS   TYPE    ARGS         DEF LINE  REFERENCES
       AMOD      REAL        2  INTRIN                33         47

STATEMENT LABELS              DEF LINE   REFERENCES
10414  5        FMT               18         17
    0  300                        49         36
    0  500                        62         59

LOOPS  LABEL     INDEX     FROM-TO     LENGTH    PROPERTIES
10226           * I          13 13        10B                 EXT REFS
10310  300      * J          36 49        34B                 EXT REFS
10361  500        J          59 62         4B     INSTACK

STATISTICS
  PROGRAM LENGTH               3236B     1694
  BUFFER LENGTH               10214B     4236
```

```
SUBROUTINE CHECK       73/74   OPT=1                          FTN 4.6+433       01/14/83  17.14.35        PAGE      1

                            SUBROUTINE CHECK( LAT)
                            REAL LAT(384)
                            A1= ABS( LAT(1))
                            A381=ABS(LAT(381))
                            IF(.NOT.((A1.LT.O.5).AND.(A381.LT.O.5))) GO TO20
                                RETURN
                   20           CONTINUE
               C            ENDIF
                            PRINT30
                   30       FORMAT(*ERROR*)
                            STOP " STOPPED IN CHECK SUBROUTINE"
                            END


       SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE     REFERENCES
    3  CHECK           1           6

VARIABLES       SN  TYPE            RELOCATION
   26  A1           REAL                                REFS        5   DEFINED       3
   27  A381         REAL                                REFS        5   DEFINED       4
    0  LAT          REAL         ARRAY      F.P.        REFS        2         3       4   DEFINED      1

FILE NAMES          MODE
       OUTPUT       FMT                      WRITES         9

INLINE FUNCTIONS    TYPE     ARGS        DEF LINE   REFERENCES
       ABS          REAL       1  INTRIN                  3          4

STATEMENT LABELS                  DEF LINE    REFERENCES
   14  20                             7           5
   22  30       FMT                  10           9

STATISTICS
  PROGRAM LENGTH                    34B         28
```

APPENDIX B

SSTGTD PROGRAM USER'S GUIDE AND PROGRAM LISTING

APPENDIX B

1. SSTGTD PROGRAM USER'S GUIDE

The standard Satellite Track Geocentric Tide Data (SSTGTD) program generates geocentric harmonic constants at SST (see Section 2) grid points. This data will be used by the STT (Section 5) program.

The following program listing shows SSTGTD written in CDC Fortran Extended for the CDC 6700 computer under the SCOPE 3.4 operating system.

Input for the SSTGTD program consist of three files and two other values using the free-format READ statement. These two values are the species number and the earth-tide amplitude of the tide that is being processed. The computed values are put on two other files (TAPE4 and TAPE5).

The following gives the control cards and data card for a sample run of the SSTGTD program for the M_2 tide.

⟨job card⟩
⟨account card⟩
FTN, R=3, A.
ATTACH, TAPE2, the SST file generated by the SST (Section 2) program.
ATTACH, TAPE1, $\xi^i_{m,n}$ (amplitude in meters) } m = 1, 2,..., 360 (longitude number)
n = 1,2,..., 168 (colatitude number)
ATTACH, TAPE3, $\delta^i_{m,n}$ (phase in degrees) } i = tidal mode being processed
Tapes 1 and 3 contain GOTD values made randomly accessible by colalitude number n.

REQUEST, TAPE4, *PF.
REQUEST, TAPE5, *PF.
LGO.
CATALOG, TAPE4, $\xi^i_{j,k}$ (amplitudes in meters) } j = 1,2,..., 383 (SST points)
CATALOG, TAPE 5, $\delta^i_{j,k}$ (phases in radians) } k = 1,2,..., 360 (SST number)
i = tidal mode being processed

⟨end of record⟩
⟨SSTGTD program⟩
⟨end of record⟩
⟨data card⟩ for i = 1 (M_2 tide): ⟨2, 0.148308⟩

2. SST GTD PROGRAM LISTING

```
                PROGRAM SSTGTD(INPUT=65,OUTPUT=65,TAPE1=65
           *    ,TAPE2,TAPE3=65
           *          , TAPE4=65, TAPE5=65 )
       C        ..SSTGTD(STANDARD SATELLITE TRACK GEOCENTRIC TIDE DATA) PROGRAM
       C             FORMERLY CALLED SSSTDT.
       C   AUTHOR
       C        L. T. SZETO
       C   LANGUAGE
       C        CDC FORTRAN EXTENDED
       C        CALLS TO
       C             ETIDE
       C             GTD
       C             JUMPS
       C             LATLON

                REAL LAM
                DIMENSION XDJK(768), XJK(384), DJK(384)
                DIMENSION LVL(192),L4(170),XN(361), X(361)
                EQUIVALENCE (XDJK(1), XJK(1)),( XDJK(385), DJK(1))
       C
       C        **SETUP RANDOM ACCESS FILE ON UNITS 1 AND 3
                CALL OPENMS( 1,LVL, 192,0)
                CALL OPENMS(3,L4,170,0)
                PI=3.14159
                ISST=2
                DTR= PI/180.
       C        **INPUT THE SPECIES(NU) AND EARTH TIDE AMPLITUDE(E)
       C        ** FOR THE CORRESPONDING TIDAL MODE.
                READ*,NU,E

       C        **FOR EACH STANDARD SATELLITE TRACK(SST) NUMBER(K).
                DO 6000 K=1,360
       C             **GENERATE AMPLITUDES AND PHASES(XJK(J),DJK(J)) FOR THE
       C             **TOTAL GEOCENTRIC PARTIAL TIDE AT EACH SST POINT(J).
                     DO 4000 J=1,383
                          CALL LATLON
           G                           ( K, J ,ISST
           Y                           , PHI, LAM, M, N, T, TB
           B                           , PSI )
       C                  LATITUDE AND LONGITUDE(PHI,LAM) OF SST
       C                  ARE IN DEGREES.
       C                ..
                        IF(.NOT.(N.GT.169)) GO TO 1020
                          XJK(J)=0.
                          DJK(J)=0.
                          GO TO 3055
       C                ELSE
        1020              CALL GTD
           G                      (N,M
           Y                      ,XD,X
           Y                      ,XN,DMN,DM1N,MM1,DMN1,DM1N1
           B                      , PSI, T, TB, ICF )
                          IF(.NOT.(ICF.EQ.1)) GO TO 1050
                               XJK(J)=0.
                               DJK(J)=0.
                               GO TO 3050
       C                  ELSE
```

```
PROGRAM SSTGTD     73/74   OPT=1                    FTN 4.6+433        01/18/83  11 40 06        PAGE     2

      1050              CONTINUE
     C                  INTERPOLATE
                        T1=1.-T
                        TB1=1.-TB
                        PSI1=1.-PSI
                        XJK(J)= PSI1*(XN(M)*T+T1*X(M))
         *                    +PSI*(XN(MM1)*TB+TB1*X(MM1))
     C                  ADD OCEAN LOADING EFFECT.
                        XJK(J)= XJK(J)* 0.933333
     C                  ..
     C                  **SKIP PHASE JUMP CHECK(JUMPS SUBROUTINE)
     C                  **WHEN N,M ARE THE SAME (XD.LE.O.O) AS THE
     C                  **PREVIOUSLY COMPUTED N,M.
                        IF(.NOT.(XD.GT.O.O)) GO TO 2080
                              CALL JUMPS(DMN,DM1N,DMN1,DM1N1)
      2080                    CONTINUE
     C                  ENDIF
     C                  ..
     C                  INTERPOLATE FOR DJK(J)
                               DJK(J)=PSI1*( DMN1*T+T1*DMN)
         *                      +PSI*(  DM1N1*TB+TB1*DM1N)
                        PHIR= PHI*DTR
                        CALL ETIDE
         G                          (E,PHIR,NU
         Y                          , EB )
     C                  ..
     C                  COMPUTE GEOCENTRIC HARMONIC CONSTANTS BY
     C                  HARMONIC ADDITION.
                        EB2= EB*EB
                        XI= XJK(J)
                        XI2= XJK(J)*XJK(J)
                        DR= DJK(J)*DTR
                        RNULK1= DTR*NU*(LAM- K+1.)
                        XJK(J)=SQRT(XI2+EB2+2*EB*XI     *COS(DR+RNULK1))
                        D1T= XI*SIN(DR)- EB*SIN(RNULK1)
                        D1D= XI*COS(DR)+ EB*COS(RNULK1)
     C                  ..
     C                  **4 QUADRANT ARCTANGENT FUNCTION ARTNQ
     C                  RETURNS DJK ,O.LE.DJK.LT.2*PI
                        DJK(J)= ARTNQ(D1T,D1D)
     C                  XJK,DJK ARE IN METERS AND RADIANS RESPECTIVELY.
      3050              CONTINUE
     C               ENDIF
      3055           CONTINUE
     C            ENDIF
      4000           CONTINUE
                  ENDDO
                  XJK(384)=K
                  BUFFER OUT(4,1) ( XJK(1), XJK(384))
                  IF(UNIT(4)) 5020,12,13
      5020        DJK(384)=K
                  BUFFER OUT(5,1) (DJK(1), DJK(384))
                  IF(UNIT(5)) 5021,12,13
      5021        CONTINUE
      6000        CONTINUE
     C         ENDDO
               PRINT6050
```

```
      PROGRAM SSTGTD     73/74    OPT=1                      FTN 4.6+433        01/18/83  11.40.06      PAGE     3

  115           6050    FORMAT(* *,*SSTGTD PROGRAM COMPLETED*)
                        CALL EXIT
                  12    STOP "12,STOPPED IN SSTGTD"
                  13    STOP "13,STOPPED IN SSTGTD"
                        END


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
 3170  SSTGTD          1

VARIABLES      SN  TYPE             RELOCATION
 4336  DJK         REAL          ARRAY              REFS         17        19        89     2*109   DEFINED      45       55
                                                        77       97       108
 3514  DMN         REAL                             REFS         48        72        77
 3517  DMN1        REAL                             REFS         48        72        77
 3515  DM1N        REAL                             REFS         48        72        77
 3520  DM1N1       REAL                             REFS         48        72        77
 3532  DR          REAL                             REFS         91        92        93   DEFINED      89
 3500  DTR         REAL                             REFS         79        89        90   DEFINED      26
 3535  D1D         REAL                             REFS         97   DEFINED        93
 3534  D1T         REAL                             REFS         97   DEFINED        92
 3502  E           REAL                             REFS         80   DEFINED        29
 3526  EB          REAL                             REFS         80      2*86        91        92      93
 3527  EB2         REAL                             REFS         91   DEFINED        86
 3521  ICF         INTEGER                          REFS         48        53
 3477  ISST        INTEGER                          REFS         36   DEFINED        25
 3504  J           INTEGER                          REFS         36        44        45        54      55       63     2*66
                                                        77       87      2*88        89        91      97
                                                  DEFINED        35
 3503  K           INTEGER                          REFS         36        90       105       108   DEFINED      32
 3475  LAM         REAL                             REFS         16        36        90
 5136  LVL         INTEGER       ARRAY              REFS         18        22
 5436  L4          INTEGER       ARRAY              REFS         18        23
 3506  M           INTEGER                          REFS         36        48      2*63
 3516  MM1         INTEGER                          REFS         48      2*63
 3507  N           INTEGER                          REFS         36        43        48
 3501  NU          INTEGER                          REFS         80        90   DEFINED        29
 3505  PHI         REAL                             REFS         36        79
 3525  PHIR        REAL                             REFS         80   DEFINED        79
 3476  PI          REAL                             REFS         26   DEFINED        24
 3512  PSI         REAL                             REFS         36        48        62        63      77
 3524  PSI1        REAL                             REFS         63        77   DEFINED        62
 3533  RNULK1      REAL                             REFS         91        92        93   DEFINED      90
 3510  T           REAL                             REFS         36        48        60        63      77
 3511  TB          REAL                             REFS         36        48        61        63      77
 3523  TB1         REAL                             REFS         63        77   DEFINED        61
 3522  T1          REAL                             REFS         63        77   DEFINED        60
 6461  X           REAL          ARRAY              REFS         18        48      2*63
 3513  XD          REAL                             REFS         48        71
 3536  XDJK        REAL          ARRAY              REFS         17      2*19
 3530  XI          REAL                             REFS         91        92        93   DEFINED      87
 3531  XI2         REAL                             REFS         91   DEFINED        88
```

```
                                                                  FTN 4.6+433       01/18/83  11.40.06       PAGE     4
          PROGRAM SSTGTD      73/74    OPT=1

VARIABLES       SN  TYPE            RELOCATION
 3536   XJK         REAL          ARRAY                 REFS        17       19       66       87      2*88     2*106
                                                     DEFINED        44       54       63       66       91      105
                                                        REFS        18       48     2*63
 5710   XN          REAL          ARRAY

FILE NAMES          MODE
     0  INPUT       FREE                      READS       29
   142  OUTPUT      FMT                       WRITES     114
   304  TAPE1
   446  TAPE2
  2511  TAPE3
  2653  TAPE4       BUF                       WRITES     106
  3015  TAPE5       BUF                       WRITES     109

EXTERNALS              TYPE    ARGS        REFERENCES
         ARTNO         REAL     2              97
         COS           REAL     1 LIBRARY      91        2*93
         ETIDE                  4              80
         EXIT                   0             116
         GTD                   14              48
         JUMPS                  4              72
         LATLON                10              36
         OPENMS                 4              22         23
         SIN           REAL     1 LIBRARY    2*92
         SQRT          REAL     1 LIBRARY      91
         UNIT          REAL     1             107        110

STATEMENT LABELS                  DEF LINE   REFERENCES
  3345   12                          117        107       110
  3346   13                          118        107       110
  3212   1020                         48         43
  3221   1050                         58         53
  3243   2080                         73         71
  3321   3050                         99         56
  3321   3055                        101         46
     0   4000                        103         35
     0   5020        INACTIVE        108        107
     0   5021        INACTIVE        111        110
     0   6000                        112         32
  3455   6050    FMT                 115        114

LOOPS   LABEL    INDEX     FROM-TO    LENGTH    PROPERTIES
  3203  6000     * K       32  112     140B                EXT REFS    EXITS    NOT INNER
  3204  4000     * J       35  103     120B                EXT REFS

EQUIV CLASSES    LENGTH     MEMBERS - BIAS NAME(LENGTH)
      XDJK         768               0 XJK     (384) *         384 DJK     (384)

STATISTICS
  PROGRAM LENGTH               4061B    2097
  BUFFER LENGTH                3157B    1647
```

```
SUBROUTINE ETIDE      73/74   OPT=1                          FTN 4.6+433       01/18/83  11.40.06        PAGE      1

 1                     SUBROUTINE ETIDE
                  G                        (E,PHIR,NU
                  Y                        , EB)
              C   AUTHOR
 5            C       L. T. SZETO
              C   LANGUAGE
              C        CDC FORTRAN EXTENDED
              C        CALLED BY
              C             SSTGTD
10            C
                       IF(.NOT.(NU.EQ.1)) GO TO 4012
                            TEMP= SIN( 2*PHIR)
                            GO TO 4013
              C        ELSE
15             4012         COSPHI= COS(PHIR)
                            CPHI2= COSPHI*COSPHI
                            IF(NU.EQ.2) TEMP= CPHI2
              C             IF(NU.EQ.O) TEMP= (3.0*CPHI2-2.)/2.0
                            IF(NU.EQ.O) TEMP= 1.5*CPHI2-1.
20             4013         CONTINUE
              C        ENDIF
                       EB=E * TEMP
                       RETURN
                       END


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE       REFERENCES
   3  ETIDE            1             23

VARIABLES        SN  TYPE              RELOCATION
   33  COSPHI        REAL                           REFS       2*16    DEFINED      15
   34  CPHI2         REAL                           REFS         17        19    DEFINED      16
    O  E             REAL                  F.P.     REFS         22    DEFINED       1
    O  EB            REAL                  F.P.  DEFINED          1        22
    O  NU            INTEGER               F.P.     REFS         11        17        19    DEFINED       1
    O  PHIR          REAL                  F.P.     REFS         12        15    DEFINED       1
   32  TEMP          REAL                           REFS         22    DEFINED      12        17        19

EXTERNALS               TYPE    ARGS          REFERENCES
        COS             REAL      1 LIBRARY       15
        SIN             REAL      1 LIBRARY       12

STATEMENT LABELS                 DEF LINE     REFERENCES
   12  4012                         15            11
   25  4013                         20            13

STATISTICS
  PROGRAM LENGTH                   35B           29
```

```
              SUBROUTINE GTD
         G                  ( N, M
         Y                     ,XD,X
         Y                     ,XN,DMN,DM1N,MM1,DMN1,DM1N1
         B                   ,PSI,T,TB,ICF )
      C  AUTHOR
      C       L. T. SZETO
      C  LANGUAGE
      C       CDC FORTRAN EXTENDED
      C       CALLED BY
      C            SSTGTD
      C
              DIMENSION XN(361),  X(361),D(361),DN(361)
              REAL LAND
              DATA NOLD/777/,N1OLD/-2/,MOLD/-2/
              DATA LAND/9.999/
      C
            XD=-.90
            IF(N.EQ.NOLD.AND.M.EQ.MOLD) GO TO 700
              XD=NOLD
      C            **RESTRICTED IN FORMULATIONS SO THAT
      C            **N.EQ.1 DOES NOT OCCURE.
                   N1=N-1
                   MM1=M-1
                   IF(MM1.EQ.0) MM1=360
                   IA=0
                   IB=0
                   ID =0
                   IE =0
                   ICF=0
              IF(.NOT.(N.NE.NOLD)) GO TO 55
      CC           **READ FROM RANDOM ACCESS FILES ON UNITS 1AND 3
                   CALL READMS(1,XN(1), 361,N1)
                   CALL READMS(3,DN(1), 361,N1)
                 IF(.NOT.(N.LT.169)) GO TO 40
                   CALL READMS(1, X(1), 361,N)
                   CALL READMS(3, D(1), 361,N)
           40      CONTINUE
      C          ENDIF
           55      CONTINUE
      C       ENDIF
                   DMN= D(M)
                   DM1N=D(MM1)
                   DMN1=DN(M)
                   DM1N1=DN(MM1)
                   IF(.NOT.(N.EQ.169)) GO TO 70
                        DM1N=999.9
                        DMN=999.9
                        X(M)=9.999
                        X(MM1)=9.999
           70           CONTINUE
      C            ENDIF
                   IF(.NOT.(XN(M).EQ.LAND)) GO TO 100
                        T=0.
                        IA=1
          100           CONTINUE
      C            ENDIF
```

```
SUBROUTINE GTD        73/74    OPT=1                    FTN 4.6+433       01/18/83  11.40.06       PAGE      2

                          IF(.NOT.(X(M).EQ.LAND)) GO TO 200
                                IB=1
                                T=1.
                200             CONTINUE
            C              ENDIF
                           IF(IA+IB .EQ.2) PSI=1.
                          IF(.NOT.(XN(MM1).EQ.LAND)) GO TO 300
                                ID=1
                                TB=O.
                300             CONTINUE
            C              ENDIF
                          IF(.NOT.(X(MM1).EQ.LAND)) GO TO 400
                                IE=1
                                TB=1.
                400             CONTINUE
            C              ENDIF
                           IF( ID+IE.EQ.2) PSI=O.
                           IF( IA+IB+ID+IE.EQ.4) ICF=1
                           NOLD=N
                           N1OLD=N1
                           MOLD=M
                700     CONTINUE
            C       ENDIF
                           RETURN
                           END


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   3  GTD             1            81

VARIABLES      SN  TYPE            RELOCATION
  211  D           REAL       ARRAY                 REFS        13        37        42        43
    O  DMN         REAL                 F.P.     DEFINED         1        42        48
    O  DMN1        REAL                 F.P.     DEFINED         1        44
    O  DM1N        REAL                 F.P.     DEFINED         1        43        47
    O  DM1N1       REAL                 F.P.     DEFINED         1        45
  762  DN          REAL       ARRAY                 REFS        13        34        44        45
  205  IA          INTEGER                          REFS        63        75   DEFINED        26        55
  206  IB          INTEGER                          REFS        63        75   DEFINED        27        59
    O  ICF         INTEGER              F.P.     DEFINED         1        30        75
  207  ID          INTEGER                          REFS        74        75   DEFINED        28        65
  210  IE          INTEGER                          REFS        74        75   DEFINED        29        70
  173  LAND        REAL                             REFS        14        53        58        64        69
                                                 DEFINED        16
    O  M           INTEGER              F.P.        REFS        19        24        42        44        49        53        58
                                                      78   DEFINED         1
    O  MM1         INTEGER              F.P.        REFS        25        43        45        50        64        69
                                                 DEFINED         1        24        25
  172  MOLD        INTEGER                          REFS        19   DEFINED        15        78
    O  N           INTEGER              F.P.        REFS        19        23        31        35        36        37        46
                                                      76   DEFINED         1
  170  NOLD        INTEGER                          REFS        19        20        31   DEFINED        15        76
```

```
     SUBROUTINE GTD          73/74    OPT=1                          FTN 4.6+433        01/18/83  11.40.06        PAGE      3

VARIABLES      SN  TYPE              RELOCATION
  204  N1          INTEGER                            REFS        33          34          77    DEFINED        23
  171  N1OLD       INTEGER                          DEFINED       15          77
    0  PSI         REAL                 F.P.        DEFINED        1          63          74
    0  T           REAL                 F.P.        DEFINED        1          54          60
    0  TB          REAL                 F.P.        DEFINED        1          66          71
    0  X           REAL       ARRAY     F.P.          REFS        13          36          58          69    DEFINED        1        49
                                                       50
    0  XD          REAL                 F.P.        DEFINED        1          18          20
    0  XN          REAL       ARRAY     F.P.          REFS        13          33          53          64    DEFINED        1

EXTERNALS          TYPE   ARGS        REFERENCES
     READMS                4                33          34          36          37

STATEMENT LABELS             DEF LINE    REFERENCES
   45  40                        38          35
   45  55                        40          31
   64  70                        51          46
   73  100                       56          53
  102  200                       61          58
  115  300                       67          64
  124  400                       72          69
  143  700                       79          19

STATISTICS
  PROGRAM LENGTH                1533B       859
```

```
SUBROUTINE JUMPS      74/74    OPT=1                     FTN 4.6+433       05/06/83  09.46.53       PAGE      1

                 SUBROUTINE JUMPS( DMN, DM1N, DMN1, DM1N1    )
C                CALLED BY
C                     SSTGTD
C                **TEST FOR 360 DEGREES PHASE JUMPS
                 D1=DMN1 -DMN
                 D2=DM1N1-DMN
                 D3=DM1N -DMN
                 D4=DM1N1-DMN1
                 D5=DM1N -DMN1
                 D6=DM1N -DM1N1
                 IF(D1.GT. 180.0) DMN1 =DMN1 -360.0
                 IF(D1.LT.-180.0) DMN  =DMN  -360.0
                 IF(D2.GT. 180.0) DM1N1=DM1N1-360.0
                 IF(D2.LT.-180.0) DMN  =DMN  -360.0
                 IF(D3.GT. 180.0) DM1N =DM1N -360.0
                 IF(D3.LT.-180.0) DMN  =DMN  -360.0
                 IF(D4.GT. 180.0) DM1N1=DM1N1-360.0
                 IF(D4.LT.-180.0) DMN1 =DMN1 -360.0
                 IF(D5.GT. 180.0) DM1N =DM1N -360.0
                 IF(D5.LT.-180.0) DMN1 =DMN1 -360.0
                 IF(D6.GT. 180.0) DM1N =DM1N -360.0
                 IF(D6.LT.-180.0) DM1N1=DM1N1-360.0
                 RETURN
                 END


   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE      REFERENCES
   3  JUMPS            1          23

VARIABLES      SN  TYPE             RELOCATION
    O  DMN         REAL                  F.P.      REFS       5       6       7      12      14      16
                                                DEFINED       1      12      14      16
    O  DMN1        REAL                  F.P.      REFS       5       8       9      11      18      20
                                                DEFINED       1      11      18      20
    O  DM1N        REAL                  F.P.      REFS       7       9      10      15      19      21
                                                DEFINED       1      15      19      21
    O  DM1N1       REAL                  F.P.      REFS       6       8      10      13      17      22
                                                DEFINED       1      13      17      22
  102  D1          REAL                            REFS      11      12  DEFINED      5
  103  D2          REAL                            REFS      13      14  DEFINED      6
  104  D3          REAL                            REFS      15      16  DEFINED      7
  105  D4          REAL                            REFS      17      18  DEFINED      8
  106  D5          REAL                            REFS      19      2C  DEFINED      9
  107  D6          REAL                            REFS      21      22  DEFINED     10

STATISTICS
  PROGRAM LENGTH               110B       72
```

```
SUBROUTINE LATLON     73/74   OPT=1                              FTN 4.6+433         01/18/83  11.40.06        PAGE     1

1                     SUBROUTINE LATLON
                 G                             ( K, J , ISST
                 Y                             , PHI, LAM, M , N, T, TB
                 B                             , PSI )
5             C   AUTHOR
              C       L. T. SZETO
              C   LANGUAGE
              C        CDC FORTRAN EXTENDED
              C        CALLED BY
10            C             SSTGTD
              C
                      REAL LAM, LAMBAR
                      REAL LAT(384), LONG(384)
                      IF(.NOT.((K.EQ.1).AND.(J.EQ.1))) GO TO 200
15                         READ(ISST) (LAT(I),I=1,384)
                           READ(ISST)(LONG(I),I=1,384)
                200        CONTINUE
              C       ENDIF
                      PHI=LAT(J)
20                    LAM=LONG(J)
              C       LATITUDE AND LONGITUDE(PHI,LAM ) FROM SST ARE IN DEGREES
                      LAMBAR= 1.5-K+ LAM
                      IF(LAMBAR.LT.0.0) LAMBAR= LAMBAR+360.
                      IF(LAMBAR.GT.360.) LAMBAR= LAMBAR-360.
25                    M= LAMBAR+1
                      P9=90.5-PHI
                      N=P9+1.
                      PSI= M- LAMBAR
                      T=N-P9
30                    TB=T
                      RETURN
                      END


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    3  LATLON            1           31

VARIABLES       SN  TYPE            RELOCATION
   63  I            INTEGER                          REFS        15        16    DEFINED      15         16
    0  ISST         INTEGER                F.P.   DEFINED         1   I/O REFS        15      16
    0  J            INTEGER                F.P.      REFS        14        19         20  DEFINED          1
    0  K            INTEGER                F.P.      REFS        14        22    DEFINED       1
    0  LAM          REAL                   F.P.      REFS        12        22    DEFINED       1          20
   62  LAMBAR       REAL                             REFS        12      2*23       2*24      25          28
                                                  DEFINED        22        23         24
   65  LAT          REAL        ARRAY                REFS        13        19    DEFINED      15
  665  LONG         REAL        ARRAY                REFS        13        20    DEFINED      16
    0  M            INTEGER                F.P.      REFS        28   DEFINED          1      25
    0  N            INTEGER                F.P.      REFS        29   DEFINED          1      27
    0  PHI          REAL                   F.P.      REFS        26   DEFINED          1      19
    0  PSI          REAL                   F.P.   DEFINED         1        28
   64  P9           REAL                             REFS        27        29    DEFINED      26
```

```
      SUBROUTINE LATLON      73/74    OPT=1                            FTN 4.6+433        01/18/83  11.40.06        PAGE      2

VARIABLES      SN  TYPE             RELOCATION
    O  T           REAL                  F.P.       REFS        30    DEFINED         1         29
    O  TB          REAL                  F.P.     DEFINED        1         30
       VARIABLES USED AS FILE NAMES, SEE ABOVE

STATEMENT LABELS               DEF LINE   REFERENCES
   15  200                        17          14

STATISTICS
  PROGRAM LENGTH                 1465B      821
```

APPENDIX C

STT PROGRAM USER'S GUIDE AND PROGRAM LISTING

APPENDIX C

1. STT PROGRAM USER'S GUIDE

The Satellite Track Tide (STT) program computes instantaneous geocentric tides at equidistant points along a given Constrained Satellite Track (CST).

The following program listing shows the STT (program) subroutine written in CDC Fortran Extended for the CDC 6700 computer under the SCOPE 3.4 operating system.

The STT subroutine is called with the following statement:

```
CALL STT  (MODES, YEAR, DAY, TIME1, NTOTAL, IUNIT, ISST,
           CSTLAT, CSTLON, ELONA, ELONB, ETIMEA, ETIMEB,
           TIDE, DT, NPTS, ISTOP)
```

where

MODES = the number of tidal modes to process

YEAR = year $\geqslant$ 1975

DAY = day of YEAR, example: February 1, 1978, DAY = 32

TIME1 = time (in sec) of 1st point of the CST to be processed relative to Greenwich midnight of DAY

NTOTAL = number of points on the CST to be processed

IUNIT = beginning unit number of (2 x MODES) consecutive units to which the SSTGTD files are attached

ISST = unit number to which the SST file is attached

CSTLAT = array containing latitudes of the lst 2 CST points in degrees

CSTLON = array containing longitudes (EAST) of the 1st 2 CST points in degrees

ELONA = equator crossing longitudes (in deg) corresponding to the 2
ELONB = consecutive ascending modes of the track containing the CST

ETIMEA = equator crossing times (in sec) relative to Greenwich midnight
ETIMEB = of DAY, (DAY-1), or (DAY+1) for ETIMEA belonging to ELONA and ETIMEB belonging to ELONB

TIDE = array containing the generated tide values

DT = time in sec between consecutive points of the CST

NPTS = number of tide values returned by STT in TIDE(1) through TIDE (NPTS), $1 \leq NPTS \leq 100$

ISTOP = flag, if ISTOP = 0, the last set of tide values have been generated for the given CST.

For each CST track to be processed, the STT subroutine (program) is called repeated until a zero is returned for the ISTOP variable. For each successive return from STT, NPTS indicates the number of successive tide values generated and stored in the TIDE array. ($1 \leq NPTS \leq 100$) Also, NPTS *must* be set to -1 before the first call to STT for each track. The BUFFER IN statement in STT bring in data files (SSTGTD) that are in binary form. The SSTGTD magnetic tapes are in coded form as described in Section 4. The SST data file is also described in Section 4. The following shows how the SSTGTD files are attached.

ATTACH, TAPE ℓ, $\xi^{i=1}_{j,k}$

ATTACH, TAPE $\ell+1$, $\delta^{i=1}_{j,k}$

ATTACH, TAPE $\ell+2$, $\xi^{2}_{j,k}$

ATTACH, TAPE $\ell+3$, $\delta^{2}_{j,k}$

⋮

ATTACH, TAPE $\ell+21$, $\xi^{11}_{j,k}$

ATTACH, TAPE $\ell+22$, $\delta^{11}_{j,k}$

i = 1,2, ..., 11 (tidal model)
j = 1,2, ..., 383 (SST points)
k = 1,2, ..., 360 (SST number)
SSTGTD files, see Section 4

2. STT PROGRAM LISTING

```
                SUBROUTINE STT
           G                 (MODES,YEAR,DAY,TIME1,NTOTAL,IUNIT,ISST
           G                 .CSTLAT, CSTLON, ELONA, ELONB,ETIMEA,ETIMEB
           Y                 , TIDE
           B                 , DT,NPTS,NMINUS)
      C         CALLS TO
      C               CONST
      C               ECROSS
      C               INTRP1
      C               INTRP2

                DIMENSION TIDE(100), TIDEB(383)
                DIMENSION CSTLON(4), CSTLAT(4)
                DIMENSION SSTLAT(383), SSTLON(383)
                DIMENSION ASTROB(11), FREQB(11)
                INTEGER YEAR, DAY
                DATA NCASE/0/

                IF(.NOT.(NPTS.LT.0)) GO TO 6080
      C               ..PERFORM THE FOLLOWING IF THIS IS
      C               THE 1ST CALL TO STT FOR THE CURRENT
      C               CST(CONSTRAINED SATELLITE TRACK)THAT
      C               IS BEING PROCESSED.
                      NCASE=0
                      REWIND ISST
      C               ..READ FROM THE SST FILE.
                      READ(ISST) (SSTLAT(I),I=1,383),SSTTS
                      READ(ISST) (SSTLON(I),I=1,383),HAT
                      CALL ECROSS
           G                  (CSTLAT,CSTLON, DAY,SSTTS,HAT
           G                   ,ETIMEA,ETIMEB,ELONA,ELONB,TIME1,NTOTAL
           Y                   , ETIME,ELONG, K, TAU1, RLATD,JCAP,MCAP,TAUN
           B                   , DT              )
                      CALL CONST
           G                 (DAY,YEAR,       ETIME,       SSTTS
           Y                   , ASTROB,FREQB,       DTAUT )

      C               ..THE 1ST ROUGH INTERPOLATION OF TIDAL
      C               HEIGHTS(TIDEB) WITH SST-SPACING ALONG
      C               THE CST THAT IS BEING PROCESSED.
                      CALL INTRP1
           G                   ( MODES,JCAP,K,MCAP,NTOTAL,RLATD
           G                   , DT, SSTTS,DTAUT,TAU1,TAUN,IUNIT
           G                   , FREQB, ASTROB
           Y                   , TIDEB                )
                      NMINUS=NTOTAL
       6080           CONTINUE
      C         ENDIF

                NPTS=100
                IF(.NOT.( NMINUS.LT.100)) GO TO 7020
                      NPTS= NMINUS
       7020           CONTINUE
      C         ENDIF

      C         ..COMPUTE INSTANTANEOUS GEOCENTRIC TIDES(TIDE)
      C         AT GIVEN CST-SPACINGS.
```

```
      SUBROUTINE STT        74/74    OPT=0 TRACE                  FTN 4.6+433        01/21/83  16.18.59        PAGE      2

                          CALL INTRP2
                       G               ( MCAP,NTOTAL, DT,SSTTS, DTAUT
   60                  G               , TAU1, NMINUS, TIDEB, NPTS
                       Y               , TIDE
                       B               , NCASE         )
                          NMINUS= NMINUS-NPTS
                          NPTOLD= NPTS
   65                     RETURN
                          END


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS       DEF LINE     REFERENCES
    4  STT                1        65

VARIABLES       SN  TYPE            RELOCATION
 2432  ASTROB       REAL         ARRAY                REFS       15       34        41
    O  CSTLAT       REAL         ARRAY    F.P.        REFS       13       29   DEFINED         1
    O  CSTLON       REAL         ARRAY    F.P.        REFS       13       29   DEFINED         1
    O  DAY          INTEGER               F.P.        REFS       16       29        34   DEFINED         1
    O  DT           REAL                  F.P.        REFS       29       41        58   DEFINED         1
  233  DTAUT        REAL                              REFS       34       41        58
    O  ELONA        REAL                  F.P.        REFS       29  DEFINED         1
    O  ELONB        REAL                  F.P.        REFS       29  DEFINED         1
  224  ELONG      * REAL                              REFS       29
  223  ETIME        REAL                              REFS       29       34
    O  ETIMEA       REAL                  F.P.        REFS       29  DEFINED         1
    O  ETIMEB       REAL                  F.P.        REFS       29  DEFINED         1
 2445  FREQB        REAL         ARRAY                REFS       15       34        41
  222  HAT          REAL                              REFS       29  DEFINED        28
  220  I            INTEGER                           REFS       27       28   DEFINED        27        28
    O  ISST         INTEGER               F.P.     DEFINED        1  I/O REFS        25        27        28
    O  IUNIT        INTEGER               F.P.        REFS       41  DEFINED         1
  230  JCAP         INTEGER                           REFS       29       41
  225  K            INTEGER                           REFS       29       41
  231  MCAP         INTEGER                           REFS       29       41        58
    O  MODES        INTEGER               F.P.        REFS       41  DEFINED         1
  204  NCASE        INTEGER                           REFS       58  DEFINED        17        24
    O  NMINUS       INTEGER               F.P.        REFS       51       52        58        63   DEFINED         1        46
                                                        63
  234  NPTOLD     * INTEGER                        DEFINED       64
    O  NPTS         INTEGER               F.P.        REFS       19       58        63        64   DEFINED         1        50
                                                        52
    O  NTOTAL       INTEGER               F.P.        REFS       29       41        46        58   DEFINED         1
  227  RLATD        REAL                              REFS       29       41
 1034  SSTLAT       REAL         ARRAY                REFS       14  DEFINED        27
 1633  SSTLON       REAL         ARRAY                REFS       14  DEFINED        28
  221  SSTTS        REAL                              REFS       29       34        41        58   DEFINED        27
  232  TAUN         REAL                              REFS       29       41
  226  TAU1         REAL                              REFS       29       41        58
    O  TIDE         REAL         ARRAY    F.P.        REFS       12       58   DEFINED         1
  235  TIDEB        REAL         ARRAY                REFS       12       41        58
    O  TIME1        REAL                  F.P.        REFS       29  DEFINED         1
```

```
      SUBROUTINE STT        74/74   OPT=0 TRACE                    FTN 4.6+433       01/21/83  16.18.59       PAGE     3

VARIABLES      SN  TYPE            RELOCATION
    0  YEAR       INTEGER               F.P.        REFS        16        34    DEFINED        1
       VARIABLES USED AS FILE NAMES, SEE ABOVE

EXTERNALS           TYPE   ARGS         REFERENCES
       CONST                  7               34
       ECROSS                20               29
       INTRP1                15               41
       INTRP2                11               58

STATEMENT LABELS              DEF LINE   REFERENCES
    63  6060                       47          19
    74  7020                       53          51

STATISTICS
  PROGRAM LENGTH                 2460B     1328
```

```
SUBROUTINE CONST        74/74    OPT=0 TRACE                    FTN 4.6+433        01/21/83  16.18.59         PAGE      1

                 SUBROUTINE CONST
         G                 (DAY,YEAR,       ETIME,        SSTTS
         Y                  , ASTROB, FREQB,        DTAUT        )
      C          CALLED BY
      C               STT

                 DIMENSION ASTRO (11), FREQ (11)
         1       ,          ASTROB(11), FREQB(11)
                 INTEGER DAY,YEAR
                 DATA PI/3.1415926535898/
                 DATA ( FREQ= 1.40519E-4, 1.45444E-4, 0.72921E-4
         1       ,0.67598E-4, 1.37880E-4, 0.72523E-4, 1.45842E-4
         2       ,0.64959E-4, 0.53234E-5, 0.26392E-5, 0.39821E-6)
                 DTR= PI/180.
                 DTAUT= 1./SSTTS
                 D=DAY+365*(YEAR-1975)+ INT((YEAR-1973)/4.0)
                 T=(27392.500528+1.0000000356*D)/ 36525.
                 T2=T*T
                 T3=T2*T

      C          **COMPUTE MEAN LONGITUDES OF SUN,MOON, AND LUNAR
      C          PERIGEE AT GREENWICH MIDNIGHT.(DEGREES)
                 HO=279.69668+ 36000.768925485*T+(3.03E-4*T2)
                 SO=270.434358+481267.88314137*T-0.001133*T2+
         1          (1.9E-6*T3)
                 PO=334.329653+4069.0340329575*T-0.010325*T2
         1          -(1.2E-5*T3)
                 HO2=HO+HO
                 SO2=SO+SO
                 SO3=SO2+SO

      C          **COMPUTE ASTRONOMICAL ARGUMENTS ,ASTRO()IN DEGREES,
      C          OF THE PARTIAL TIDES.
                 ASTRO( 1)=HO2-SO2
                 ASTRO( 2)=0.
                 ASTRO( 3)=HO+90.
                 ASTRO( 4)=HO-SO2-90.
                 ASTRO( 5)=HO2-SO3+PO
                 ASTRO( 6)=-HO-90.
                 ASTRO( 7)=HO2
                 ASTRO( 8)=HO-SO3+PO-90.
                 ASTRO( 9)=SO2
                 ASTRO(10)=SO-PO
                 ASTRO(11)=HO2
                 DO 6060 I=1,11
                      FREQB(I)= FREQ(I)*SSTTS
                      ASTROB(I)=FREQ(I)*ETIME- 2.0*FREQB(I)+ASTRO(I)*DTR
       6060           CONTINUE
      C          ENDDO
                 RETURN
                 END
```

```
      SUBROUTINE CONST       74/74    OPT=0 TRACE                    FTN 4.6+433        01/21/83  16.18.59        PAGE      2

      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    4  CONST             1           50

VARIABLES      SN  TYPE             RELOCATION
  220  ASTRO      REAL        ARRAY                    REFS        7       47   DEFINED       34       35       36       37
                                                         38       39       40       41       42       43       44
    0  ASTROB     REAL        ARRAY       F.P.         REFS        7  DEFINED        1       47
  205  D          REAL                                 REFS       17  DEFINED       16
    0  DAY        INTEGER                 F.P.         REFS        9       16   DEFINED        1
    0  DTAUT      REAL                    F.P.      DEFINED        1       15
  204  DTR        REAL                                 REFS       47  DEFINED       14
    0  ETIME      REAL                    F.P.         REFS       47  DEFINED        1
  233  FREQ       REAL        ARRAY                    REFS        7       46       47  DEFINED       11
    0  FREQB      REAL        ARRAY       F.P.         REFS        7       47   DEFINED        1       46
  211  HO         REAL                                 REFS     2*28       36       37       39       41
                                                    DEFINED       23
  214  HO2        REAL                                 REFS       34       38       40       44  DEFINED       28
  217  I          INTEGER                              REFS     2*46     4*47   DEFINED       45
  160  PI         REAL                                 REFS       14  DEFINED       10
  213  PO         REAL                                 REFS       38       41       43  DEFINED       26
    0  SSTTS      REAL                    F.P.         REFS       15       46   DEFINED        1
  212  SO         REAL                                 REFS     2*29       30       43  DEFINED       24
  215  SO2        REAL                                 REFS       30       34       37       42  DEFINED       29
  216  SO3        REAL                                 REFS       38       41   DEFINED       30
  206  T          REAL                                 REFS     2*18       19       23       24       26
                                                    DEFINED       17
  207  T2         REAL                                 REFS       19       23       24       26  DEFINED       18
  210  T3         REAL                                 REFS       24       26   DEFINED       19
    0  YEAR       INTEGER                 F.P.         REFS        9     2*16   DEFINED        1

INLINE FUNCTIONS    TYPE    ARGS        DEF LINE   REFERENCES
       INT        INTEGER     1  INTRIN                  16

STATEMENT LABELS                DEF LINE    REFERENCES
    0  6060                        48          45

LOOPS  LABEL     INDEX      FROM-TO      LENGTH     PROPERTIES
  142  6060      I            45 48         14B          OPT

STATISTICS
  PROGRAM LENGTH                  265B      181
```

```
SUBROUTINE ECROSS      74/74    OPT=O TRACE                  FTN 4.6+433        01/21/83  16.18.59        PAGE      1

                    SUBROUTINE ECROSS
              G                      (CSTLAT,CSTLON, D, SSTTS, HAT
              G                      ,ETIMEA,ETIMEB,ELONA,ELONB,TIME1,NTOTAL
              Y                      ,ETIME, ELONG, K, TAU1, RLATD,JCAP,MCAP,TAUN
              B                      , DT              )
        C           CALLED BY
        C                STT

                    INTEGER D
                       REAL   CSTLAT(  4), CSTLON(  4)
                    RL1=360.-ELONB+ELONA
                    IF( RL1.LT.360.) RL1=RL1+360.
                    THAT= ETIMEB- ETIMEA
                    IF( THAT.LT.O.) THAT=THAT+86400
                    TAUHAT= 380.*SSTTS
                    TAU1= TIME1- ETIMEA
                    T3= 3.* THAT
                    IF(.NOT.( TAU1.GT.T3)) GO TO 1020
                         TAU1= TAU1-86400.
                         TIME1=TIME1-86400.
                         D=D+1
         1020            CONTINUE
        C           ENDIF
                    IF(.NOT.( TAU1.LT.-T3)) GO TO 1030
                         TAU1= TAU1+86400.
                         TIME1= TIME1+86400.
                         D=D-1
         1030            CONTINUE
        C           ENDIF
                    SSTTS2= SSTTS/2.
                    TAUN=TAU1+ (NTOTAL-1)*DT
        C
        C           ..COMPUTE LONGITUDE(ELONG) AT WHICH THE CST CROSSES
        C           LATITUDE LINE SSTLAT(JCAP)
        C           ..COMPUTE THE TIME(ETIME) AT WHICH THE CST CROSSES
        C           LATITUDE LINE SSTLAT(JCAP)
                    IF(.NOT.((TAU1.LT.-SSTTS2).OR.(TAUN-TAUHAT.GT.SSTTS2)))GOTO1070
                         STOP "STOPPED IN ECROSS.CHECK TRACK DATA"
         1070            CONTINUE
                         HH= TAUHAT/THAT
                         DT= DT*HH
                         ETIME= ETIMEA
                         TAU1= TAU1+HH
                         ELONG=ELONA+ .5*(RL1- HAT)
                         IF(ELONG.LT.O.)ELONG=ELONG+360.
                         IF(ELONG.GT.360.) ELONG=ELONG-360.
        C           ENDIF
                    IF(.NOT.(ABS(TAU1).LT.SSTTS)) GO TO 1090
                         DL1= CSTLON(1)-CSTLON(2)
                         IF( DL1.LT.O.) DL1=DL1+360.
                         PHI= CSTLAT(1)/( CSTLAT(2)-CSTLAT(1))
                         DL= ELONG-CSTLON(1)
                         IF(DL.LT.-10.) DL=DL+360.
                         DLP= PHI*DL1
                         TAU1P=PHI*DT
                       IF(.NOT.(.NOT.((ABS(TAU1-TAU1P).GT.(.4*SSTTS)).OR.
               1         (ABS(DL-DLP).GT.O.4))))GOTO 3030
```

```
      SUBROUTINE ECROSS     74/74   OPT=0 TRACE                  FTN 4.6+433        01/21/83  16.18.59        PAGE      2

                               ETIME=ETIME+ TAU1- TAU1P
                               TAU1= TAU1P
                               ELONG= CSTLON(1)+ DLP
                               IF(ELONG.LT.0.) ELONG=ELONG+360.
                               IF(ELONG.GT.360.)ELONG=ELONG-360.
                               GO TO 3040
                  C          ELSE
                   3030        CONTINUE
                               STOP "STOPPED IN ECROSS, CHECK TRACK DATA"
                   3040        CONTINUE
                  C          ENDIF
                   1090        CONTINUE
                  C         ENDIF
                  C         **COMPUTE K-BRACKETS OF THE CST
                            EL=361.-ELONG
                            K= INT(EL)
                            RLATD= EL-K
                            IF( K.EQ.361) K=1
                            JCAP= INT(2.+ TAU1/SSTTS)
                            MCAP= INT(4.- JCAP+ TAUN/SSTTS)
                            TAU1= TAU1-(JCAP-2)*SSTTS
                            RETURN
                            END


      SYMBOLIC REFERENCE MAP (R=3)

 ENTRY POINTS     DEF LINE     REFERENCES
    4  ECROSS          1           79

 VARIABLES      SN  TYPE           RELOCATION
     0  CSTLAT      REAL       ARRAY    F.P.         REFS        10      3*51   DEFINED       1
     0  CSTLON      REAL       ARRAY    F.P.         REFS        10      2*49        52      60   DEFINED        1
     0  D           INTEGER             F.P.         REFS         9        21        27 DEFINED        1       21       27
   322  DL          REAL                             REFS      2*53        56   DEFINED      52       53
   323  DLP         REAL                             REFS        56        60   DEFINED      54
   320  DL1         REAL                             REFS      2*50        54   DEFINED      49       50
     0  DT          REAL                F.P.         REFS        31        41        55 DEFINED        1       41
   325  EL          REAL                             REFS        73        74   DEFINED      72
     0  ELONA       REAL                F.P.         REFS        11        44   DEFINED       1
     0  ELONB       REAL                F.P.         REFS        11   DEFINED         1
     0  ELONG       REAL                F.P.         REFS      2*45      2*46        52    2*61     2*62       72
                                                  DEFINED         1        44        45      46       60       61       62
     0  ETIME       REAL                F.P.         REFS        58   DEFINED         1      42       58
     0  ETIMEA      REAL                F.P.         REFS        13        16        42 DEFINED        1
     0  ETIMEB      REAL                F.P.         REFS        13   DEFINED         1
     0  HAT         REAL                F.P.         REFS        44   DEFINED         1
   317  HH          REAL                             REFS        41        43   DEFINED      40
     0  JCAP        INTEGER             F.P.         REFS        77        78   DEFINED       1       76
     0  K           INTEGER             F.P.         REFS        74        75   DEFINED       1       73       75
     0  MCAP        INTEGER             F.P.      DEFINED         1        77
     0  NTOTAL      INTEGER             F.P.         REFS        31   DEFINED         1
   321  PHI         REAL                             REFS        54        55   DEFINED      51
     0  RLATD       REAL                F.P.      DEFINED         1        74
```

```
      SUBROUTINE ECROSS      74/74   OPT=0 TRACE                    FTN 4.6+433       01/21/83  16.18.59      PAGE      3

VARIABLES      SN  TYPE              RELOCATION
  312  RL1         REAL                          REFS        2*12       44    DEFINED      11        12
    0  SSTTS       REAL                 F.P.     REFS          15       30         48      56        76        77        78
                                              DEFINED           1
                                                 REFS        2*37  DEFINED         30
  316  SSTTS2      REAL                          REFS          37       40    DEFINED      15
  314  TAUHAT      REAL                          REFS          37       77    DEFINED       1        31
    0  TAUN        REAL                 F.P.     REFS          18       19         24      25        31        37        43
    0  TAU1        REAL                 F.P.     REFS          18       19         24      25        31        37        43
                                                   48          56       58         76      78   DEFINED         1        16
                                                   19          25       43         59      78
  324  TAU1P       REAL                          REFS          56       58         59  DEFINED       55
  313  THAT        REAL                          REFS        2*14       17         40  DEFINED       13        14
    0  TIME1       REAL                 F.P.     REFS          16       20         26  DEFINED        1        20        26
  315  T3          REAL                          REFS          18       24    DEFINED      17

INLINE FUNCTIONS   TYPE    ARGS         DEF LINE   REFERENCES
       ABS         REAL      1  INTRIN                  48       2*56
       INT         INTEGER   1  INTRIN                  73         76       77

STATEMENT LABELS                 DEF LINE     REFERENCES
   54  1020                         22           18
   71  1030                         28           24
  113  1070                         39           37
  237  1090                         69           48
  233  3030                         65           56
  236  3040                         67           63

STATISTICS
  PROGRAM LENGTH                   340B         224
```

```
SUBROUTINE INOUT      74/74    OPT=0 TRACE                    FTN 4.6+433        01/21/83  16.18.59        PAGE     1

                        SUBROUTINE INOUT( IN, OUT ,X, D, II)
            C           CALLED BY
            C                SSTGTD
                        DIMENSION X(II) ,D(II)
                        INTEGER OUT,OT1
                        IF(.NOT. (IN.NE.0)) GO TO 22
                             BUFFER  IN( IN,1) ( X(1), X( II))
                             IN1= IN+1
                             IF(UNIT( IN)) 20,12,13
                 20          CONTINUE
                             BUFFER  IN(IN1,1) ( D(1), D( II))
                             IF(UNIT(IN1)) 22,12,13
                 22          CONTINUE
            C           ENDIF
            C
                        IF(.NOT.(OUT.NE.0)) GO TO 30
                             BUFFER OUT(OUT,1) ( X(1), X( II))
                             IF(UNIT(OUT)) 30,12,13
                 30          CONTINUE
            C           ENDIF
                        RETURN
                 12     STOP "12,SUBROUTINE INOUT"
                 13     STOP "13,SUBROUTINE INOUT"
                        END


    SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   4  INOUT          1              21

VARIABLES      SN  TYPE          RELOCATION
   0  D            REAL      ARRAY    F.P.       REFS      4   DEFINED      1       2*11
   0  II           INTEGER            F.P.       REFS    2*4        7      11         17   DEFINED      1
   0  IN           INTEGER            F.P.       REFS      6        8       9    DEFINED         1
                                               I/O REFS    7
 104  IN1          INTEGER                       REFS     12   DEFINED      8    I/O REFS       11
 103  OT1       *  INTEGER   *UNDEF              REFS      5
   0  OUT          INTEGER            F.P.       REFS      5       16      18    DEFINED         1
                                               I/O REFS   17
   0  X            REAL      ARRAY    F.P.       REFS      4     2*17  DEFINED         1       2*7
      VARIABLES USED AS FILE NAMES, SEE ABOVE

EXTERNALS          TYPE    ARGS        REFERENCES
      UNIT         REAL      1              9        12        18

STATEMENT LABELS                DEF LINE   REFERENCES
  55  12                           22          9        12        18
  57  13                           23          9        12        18
   0  20          INACTIVE         10          9
  36  22                           13          6        12
  53  30                           19         16        18
```

```
      SUBROUTINE INOUT       74/74    OPT=0 TRACE                  FTN 4.6+433       01/21/83  16.18.59        PAGE      2

 STATISTICS
   PROGRAM LENGTH                 113B       75
```

```
                SUBROUTINE INTRP1
          G                       (  MODES, JCAP, K, MCAP, NTOTAL, RLATD
          G                       , DT, SSTTS, DTAUT, TAU1, TAUN,IUNIT
          G                       .                 FREQB, ASTROB
          Y                       , TIDEB                  )
       C        CALLED BY
       C             STT
       C        CALLS TO
       C             SR
       C             SSTGTD

                DIMENSION FREQB(11), ASTROB(11),TIDEB(383)
                DIMENSION X1(384), X2(384), D1(384), D2(384)
                DATA PI/3.14159265/, PIPI/6.28318531/
                DATA KOLD/-999/, JCAPO/-999/

                J1Z383= 383-JCAP+1
       C        **OBTAIN AMPLITUDES(   ) AND PHASES(   )
       C        WHICH ENCLOSES THE CST TO BE PROCESSED
       C        **IF NOT 1ST CALL TO INTRP1
                IF(.NOT.(KOLD.NE.-999)) GO TO 1065
       C             **RESTORE TIDEB() VALUES, IF POSSIBLE
                     IF(.NOT.(K.EQ.KOLD. AND .JCAP.GE.JCAPO)) GO TO 1060
                          ISR=2
                          CALL SR
          G                       ( ISR, JCAP, MCAP
          B                       , TIDEB, X1                  )
        1060              CONTINUE
       C             ENDIF
        1065         CONTINUE
       C        ENDIF
       C
                IF(.NOT.((K.EQ.KOLD.AND.(JCAP.LT.JCAPO)).OR.K.NE.
          *          KOLD)) GO TO 6020
                     CALL MOVE(0.,TIDEB(1),383)
                     DO 6010 I=1, MODES
                          J=JCAP
                          CALL SSTGTD
          G                          ( K, IUNIT, I,KOLD
          Y                          , X1,X2, D1, D2              )
       C                  **D1 AND D2 VALUES ARE IN RADIANS
       C
       C                  ..COMPUTE THE 1ST ROUGH TIDAL HEIGHTS(TIDEB)
       C                  WITH SST-SPACING ALONG THE CST BY
       C                  INTERPOLATING BETWEEN THE 2 SSTGTD TRACKS
       C                  THAT BOUND THE CST.
                          DO 5070 M=1,J1Z383
       C                       **CHECK FOR LAND PTS.
                               RL2= RLATD
                               RL1=1.
                               IF(.NOT.(X1(J).LE.0.)) GO TO 2050
                                    RL2=1.
        2050                        CONTINUE
       C                       ENDIF
                               IF(.NOT.(X2(J).GT.0.)) GOTO 2055
                                    RL1=1.-RLATD
        2055                        CONTINUE
```

```
SUBROUTINE INTRP1      74/74    OPT=0 TRACE                  FTN 4.6+433        01/21/83  16.18.59        PAGE     2

          C                       ENDIF
                                  XM=RL1*X1(J)+ RL2*X2(J)
          C                       **D1 AND D2 VALUES ARE IN RADIANS
                                  D1J=D1(J)
                                  D2J=D2(J)
                                  DMD=D1J-D2J
                                  IF(DMD.GT.PI) D2J=D2J+PIPI
                                  IF(DMD.LT.-PI)D1J=D1J+PIPI
                                  DM=RL1*D1J+ RL2*D2J
                                  IF(.NOT.(I.EQ.2)) GO TO 3040
                                       TIDEB(M)=TIDEB(M)+ XM*0.28
               1                       *COS(FREQB(7)*J+ ASTROB(7)-
               2                       (DM-0.0349))
                                       GO TO 3050
          C                       ELSE
           3040                        TIDEB(M)=TIDEB(M)+ XM*
               1                       COS(FREQB(I)*J+ ASTROB(I)- DM)
           3050                        CONTINUE
          C                       ENDIF
                                  J=J+1
           5070                   CONTINUE
          C                  ENDDO
           6010              CONTINUE
          C             ENDDO
          C             ..STORE THE 1ST ROUGH TIDAL HEIGHTS(TIDEB) IN
          C             THEIR CORRECT SST-SPACING POSITIONS.
                        ISR=!
                        CALL SR
               G               ( ISR, JCAP, MCAP
               B               , TIDEB, X1             )
           6020         CONTINUE
          C        ENDIF
                   KOLD=K
                   JCAPO=JCAP
                   RETURN
                   END
```

```
     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    4  INTRP1           1           92

VARIABLES      SN  TYPE            RELOCATION
     0  ASTROB      REAL        ARRAY      F.P.          REFS         12         68         73   DEFINED          1
   303  DM          REAL                                 REFS         68         73    DEFINED         66
   302  DMD         REAL                                 REFS         64         65    DEFINED         63
     0  DT          REAL       *UNUSED     F.P.       DEFINED          1
     0  DTAUT       REAL       *UNUSED     F.P.       DEFINED          1
  1704  D1          REAL        ARRAY                    REFS         13         38         61
   300  D1J         REAL                                 REFS         63         65         66   DEFINED         61         65
  2504  D2          REAL        ARRAY                    REFS         13         38         62
   301  D2J         REAL                                 REFS         63         64         66   DEFINED         62         64
     0  FREQB       REAL        ARRAY      F.P.          REFS         12         68         73   DEFINED          1
```

```
      SUBROUTINE INTRP1     74/74   OPT=O TRACE                  FTN 4.6+433       01/21/83  16.18.59      PAGE     3

VARIABLES      SN  TYPE            RELOCATION
  272  I           INTEGER                         REFS        38         67        2*73   DEFINED      36
  271  ISR         INTEGER                         REF.        25         85     DEFINED      24        84
    O  IUNIT       INTEGER               F.P.      REFS        38    DEFINED           1
  273  J           INTEGER                         REFS        51         55        2*59      61        62        68        73
                                                      77  DEFINED         37          77
    O  JCAP        INTEGER               F.P.      REFS        17         23          25      33        37        85        91
                                                 DEFINED        1
  262  JCAPO       INTEGER                         REFS        23         33     DEFINED      15        91
  270  J1Z383      INTEGER                         REFS        47    DEFINED          17
    O  K           INTEGER               F.P.      REFS        23       2*33          38      90   DEFINED         1
  261  KOLD        INTEGER                         REFS        21         23        2*33      38   DEFINED        15        90
  274  M           INTEGER                         REFS      2*68       2*73     DEFINED      47
    O  MCAP        INTEGER               F.P.      REFS        25         85     DEFINED       1
    O  MODES       INTEGER               F.P.      REFS        36    DEFINED           1
    O  NTOTAL      INTEGER      *UNUSED  F.P.    DEFINED        1
  257  PI          REAL                            REFS        64         65     DEFINED      14
  260  PIPI        REAL                            REFS        64         65     DEFINED      14
    O  RLATD       REAL                  F.P.      REFS        49         56     DEFINED       1
  276  RL1         REAL                            REFS        59         66     DEFINED      50        56
  275  RL2         REAL                            REFS        59         66     DEFINED      49        52
    O  SSTTS       REAL         *UNUSED  F.P.    DEFINED        1
    O  TAUN        REAL         *UNUSED  F.P.    DEFINED        1
    O  TAU1        REAL         *UNUSED  F.P.    DEFINED        1
    O  TIDEB       REAL          ARRAY   F.P.      REFS        12         25          35      68        73        85
                                                 DEFINED        1         68          73
  277  XM          REAL                            REFS        68         73     DEFINED      59
  304  X1          REAL          ARRAY             REFS        13         25          38      51        59        85
 1104  X2          REAL          ARRAY             REFS        13         38          55      59

EXTERNALS           TYPE    ARGS       REFERENCES
       COS          REAL      1 LIBRARY     68          73
       MOVE                   3             35
       SR                     5             25          85
       SSTGTD                 8             38

STATEMENT LABELS              DEF LINE    REFERENCES
   44  1060                       28          23
   45  1065                       30          21
  103  2050                       53          51
  112  2055                       57          55
  167  3040                       73          67
  202  3050                       75          71
    O  5070                       78          47
    O  6010                       80          36
  223  6020                       88          33

LOOPS  LABEL     INDEX      FROM-TO    LENGTH     PROPERTIES
   61  6010      * I         36 80      131B                EXT REFS  NOT INNER
   71  5070      * M         47 78      116B                EXT REFS

STATISTICS
  PROGRAM LENGTH               3346B     1766
```

```
                SUBROUTINE INTRP2
          G                       (MCAP, NTOTAL, DT.SSTTS, DTAUT
          G                       , TAU1,NMINUS ,      TIDEB ,NPTS
          Y                       , TIDE
          B                       , NCASE            )
      C         ..INTRP2 COMPUTES INSTANTANEOUS GEOCENTRIC
      C         TIDES(TIDE) AT GIVEN CST-SPACINGS BY
      C         USING A "CUBIC-PARABOLIC SPLINE" INTERPOLATION
      C         OF THE TIDEB VALUES.

      C         CALLED BY
      C               SST
      C         CALLS TO
      C               NCASE1
      C               NCASE2
      C               NCASE3
      C               NCASE4
      C               NCASE5
                DIMENSION TIDE(100), TIDEB(383)
                LOGICAL T1,T11,T12,T111,T112,T1121,T1122
                LOGICAL T2,T21,T22,T121,T122

                IF(.NOT.(NCASE.EQ.O)) GO TO 2010
                      T1=.F.
                      T2=.F.
                      T11  =.FALSE.
                      T111 =.FALSE.
                      T112 =.FALSE.
                      T1121=.FALSE.
                      T1122=.FALSE.
                      T12  =.FALSE.
                      T121 =.FALSE.
                      T122 =.FALSE.
                      T21  =.FALSE.
                      T22  =.FALSE.
                      T1T=TIDEB(1)
                      T2T=TIDEB(2)
                      T3T=TIDEB(3)
                      T4T=TIDEB(4)
                      IF(.NOT.(MCAP.GT.2.AND.(T2T.NE.O.))) GO TO 1010
                            T1=.T.
                            GO TO 1015
      C               ELSE
       1010                 T2=.T.
       1015                 CONTINUE
      C               ENDIF
                      IF(.NOT.( T3T.NE.O.)) GO TO 1020
                            T11=.T.
                            GO TO 1025
      C               ELSE
       1020                 T12=.T.
       1025                 CONTINUE
      C               ENDIF
                      IF(.NOT.(T1T.NE.O.)) GO TO 1030
                            T111=.T.
                            T121=.T.
                            GO TO 1035
```

```
SUBROUTINE INTRP2     74/74   OPT=0 TRACE              FTN 4.6+433      01/21/83  16.18.59      PAGE    2

        C          ELSE
         1030            T112=.T.
                         T122=.T.
         1035            CONTINUE
        C          ENDIF
                   IF(.NOT.(MCAP.GT.3.AND.(T4T.NE.0.))) GO TO 1040
                         T1121=.T.
                         GO TO 1045
        C          ELSE
         1040            T1122=.T.
         1045            CONTINUE
        C          ENDIF
                   IF(.NOT.(MCAP.LE.2.AND.T2T.NE.0.0.AND.
             *           T1T.NE.0.0)) GO TO 1050
                         T21=.T.
                         GO TO 1055
        C          ELSE
         1050            T22=.T.
         1055            CONTINUE
        C          ENDIF
                   TAU=TAU1
                   M=1
                   IF(T1.AND.T11.AND.T111) NCASE=3
                   IF(.NOT.(T1.AND.T11.AND.T112.AND. T1121))GOTO1060
                         NCASE=3
                         TAU=TAU1-DT
                         M=2
         1060            CONTINUE
        C          ENDIF
                   IF(.NOT.(T1.AND.T11.AND.T112.AND.T1122))GOTO1065
                         NCASE=2
                         TAU=TAU1-DT
                         M=2
         1065            CONTINUE
        C          ENDIF
                   IF(T1.AND.T12.AND.T121) NCASE=2
                   IF(T1.AND.T12.AND.T122) NCASE=1
                   IF(T2.AND.T21)          NCASE=2
                   IF(T2.AND.T22)          NCASE=1
         2010      CONTINUE
        C       ENDIF
                TT1=DTAUT/2.
                TT2=TT1+DTAUT
                TT3=TT2+DTAUT
                   NEND=NPTS
        C       CASE ENTRY
                   GO TO( 3010, 3020, 3030, 3040, 3050)NCASE
        C          CASE 1
        C          ..CONSTANT INTERPOLATION
         3010      CALL NCASE1
             G                  ( TIDEB,       NEND
             B                  , TIDE )
                   GO TO 4020
        C          ..LINEAR INTERPOLATION
         3020      CALL NCASE2
             G                  ( TIDEB, M,    NEND, DT, DTAUT
             *                  , NTOTAL,NMINUS, TIDE, TAU  )
```

```
      SUBROUTINE INTRP2      74/74    OPT=O TRACE                  FTN 4.6+433        01/21/83  16.18.59        PAGE      3

 115                        GO TO 4020
                C           ..PARABOLIC INTERPOLATION
                 3030       CALL NCASE3
                     G                ( TIDEB,SSTTS,NEND,DT, MCAP
                     B                 , TIDE, M, TAU,NCASE )
 120                        GO TO 4020
                C           ..CUBIC PARABOLIC INTERPOLATION
                 3040       CALL NCASE4
                     G                (TIDEB, 1, 100,SSTTS, DT
                     G                ,TT1,TT2, TT3, MCAP
 125                 B                ,TIDE,M, TAU, NCASE)
                            GO TO 4020
                C           ..PARABOLIC END-POINT INTERPOLATION
                 3050       CALL NCASE5
                     G                (TIDEB, 1, 100
 130                 G                ,TT1, TT2, DT
                     B                , TIDE, M, TAU)
                 4020       CONTINUE
                C       ENDCASE
                        RETURN
 135                    END


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    4  INTRP2          1          134

VARIABLES        SN  TYPE            RELOCATION
     O  DT            REAL                    F.P.        REFS        83       89      112      117      122      128
                                                       DEFINED         1
     O  DTAUT         REAL                    F.P.        REFS        99      100      101      112  DEFINED        1
   442  M             INTEGER                             REFS       112      117      122      128  DEFINED       79       84
                                                            90
     O  MCAP          INTEGER                 F.P.        REFS        40       63       70      117      122
                                                       DEFINED         1
     O  NCASE         INTEGER                 F.P.        REFS        23      104      117      122  DEFINED        1       80
                                                            82        88       93       94       95       96
   446  NEND          INTEGER                             REFS       107      112      117  DEFINED      102
     O  NMINUS        INTEGER                 F.P.        REFS       112  DEFINED        1
     O  NPTS          INTEGER                 F.P.        REFS       102  DEFINED        1
     O  NTOTAL        INTEGER                 F.P.        REFS       112  DEFINED        1
     O  SSTTS         REAL                    F.P.        REFS       117      122  DEFINED        1
   441  TAU           REAL                                REFS       112      117      122      128  DEFINED       78       83
                                                            89
     O  TAU1          REAL                    F.P.        REFS        78       83       89  DEFINED        1
     O  TIDE          REAL         ARRAY      F.P.        REFS        19      107      112      117      122      128
                                                       DEFINED         1
     O  TIDEB         REAL         ARRAY      F.P.        REFS        19       36       37       38       39      107      112
                                                           117       122      128  DEFINED        1
   443  TT1           REAL                                REFS       100      122      128  DEFINED       99
   444  TT2           REAL                                REFS       101      122      128  DEFINED      100
   445  TT3           REAL                                REFS       122  DEFINED      101
   421  T1            LOGICAL                             REFS        20       80       81       87       93       94
```

```
      SUBROUTINE INTRP2     74/74   OPT=0 TRACE                       FTN 4.6+433       01/21/83  16.18.59        PAGE     4

VARIABLES      SN  TYPE             RELOCATION
                                                 DEFINED      24          41
  435  T1T         REAL                             REFS      54          70    DEFINED         36
  422  T11         LOGICAL                          REFS      20          80          81        87    DEFINED        26        48
  424  T111        LOGICAL                          REFS      20          80    DEFINED         27          55
  425  T112        LOGICAL                          REFS      20          81          87  DEFINED          28        59
  426  T1121       LOGICAL                          REFS      20          81    DEFINED         29          64
  427  T1122       LOGICAL                          REFS      20          87    DEFINED         30          67
  423  T12         LOGICAL                          REFS      20          93          94  DEFINED          31        51
  433  T121        LOGICAL                          REFS      21          93    DEFINED         32          56
  434  T122        LOGICAL                          REFS      21          94    DEFINED         33          60
  430  T2          LOGICAL                          REFS      21          95          96  DEFINED          25        44
  436  T2T         REAL                             REFS      40          70    DEFINED         37
  431  T21         LOGICAL                          REFS      21          95    DEFINED         34          72
  432  T22         LOGICAL                          REFS      21          96    DEFINED         35          75
  437  T3T         REAL                             REFS      47    DEFINED          38
  440  T4T         REAL                             REFS      63    DEFINED          39

EXTERNALS            TYPE    ARGS         REFERENCES
          NCASE1                3             107
          NCASE2                9             112
          NCASE3                9             117
          NCASE4               13             122
          NCASE5                9             128

STATEMENT LABELS                DEF LINE   REFERENCES
   64  1010                        44          40
   66  1015                        45          42
   75  1020                        51          47
   77  1025                        52          49
  110  1030                        59          54
  114  1035                        61          57
  124  1040                        67          63
  126  1045                        68          65
  140  1050                        75          70
  142  1055                        76          73
  167  1060                        85          81
  203  1065                        91          87
  226  2010                        97          23
  254  3010                       107         104
  262  3020                       112         104
  276  3030                       117         104
  312  3040                       122         104
  326  3050                       128         104
  335  4020                       132         110        115        120        126

STATISTICS
  PROGRAM LENGTH                 447B         295
```

```
SUBROUTINE NCASE1     74/74   OPT=0 TRA:E                 FTN 4.6+433       01/21/83  16.18.59       PAGE     1

1                    SUBROUTINE NCASE1
             G                       ( TIDEB,        NEND
             B                       , TIDE             )
          C          CALLED BY
5         C              INTRP2
                     DIMENSION TIDE(100), TIDEB(383)
          C          **COMPUTE
                     DO 2020 N=1,NEND
                         TIDE(N)=TIDEB(1)+ TIDEB(2)
10          2020         CONTINUE
          C          ENDDO
                     RETURN
                     END


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE      REFERENCES
   4  NCASE1         1          12

VARIABLES     SN  TYPE           RELOCATION
  27  N           INTEGER                           REFS         9    DEFINED        8
   0  NEND        INTEGER                  F.P.     REFS         8    DEFINED        1
   0  TIDE        REAL        ARRAY        F.P.     REFS         6    DEFINED        1        9
   0  TIDEB       REAL        ARRAY        F.P.     REFS         6        2*9   DEFINED       1

STATEMENT LABELS             DEF LINE   REFERENCES
   0  2020                      10          8

LOOPS  LABEL    INDEX       FROM-TO     LENGTH    PROPERTIES
  20   2020     N             8 10         6B       INSTACK

STATISTICS
  PROGRAM LENGTH               36B       30
```

```
SUBROUTINE NCASE2      74/74    OPT=O TRACE                    FTN 4.6+433        01/21/83  16.18.59        PAGE      1

                     SUBROUTINE NCASE2
               G                       ( TIDEB, M,       NEND, DT, DTAUT
               G                       ,NTOTAL, NMINUS
               Y                       ,TIDE ,TAU     )
          C          ..CASE2 IS LINEAR INTERPOLATION
          C          FOR 2 OCEANIC DATA, TIDEB(M) AND
          C          TIDEB(M+1) NOT EQUAL TO 0.0

          C          CALLED BY
          C                INTRP2
                     DIMENSION TIDE(100), TIDEB(383)
                     N1=1
                     IF(.NOT.(NTOTAL.EQ.NMINUS)) GOTO 3010
                           N1=2
                           A=DTAUT*( TIDEB(M+1)- TIDEB(M))
                           B= A*DT
                           TIDE(1)= TIDEB(M)+ A*TAU
            3010           CONTINUE
          C          ENDIF
                     IF(   N1.EQ.1) NM1=100
                     IF(   N1.EQ.2) NM1=1
                     DO 3090 I=N1,NEND
                           TIDE(I)= TIDE(NM1)+B
                           NM1=I
            3090           CONTINUE
          C          ENDDO
                     RETURN
                     END


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS       DEF LINE       REFERENCES
    4  NCASE2            1           27

VARIABLES      SN  TYPE             RELOCATION
   73  A           REAL                               REFS        16         17   DEFINED       15
   74  B           REAL                               REFS        23    DEFINED        16
    0  DT          REAL                     F.P.      REFS        16    DEFINED         1
    0  DTAUT       REAL                     F.P.      REFS        15    DEFINED         1
   76  I           INTEGER                            REFS        23         24   DEFINED       22
    0  M           INTEGER                  F.P.      REFS      2*15         17   DEFINED        1
    0  NEND        INTEGER                  F.P.      REFS        22    DEFINED         1
    0  NMINUS      INTEGER                  F.P.      REFS        13    DEFINED         1
   75  NM1         INTEGER                            REFS        23    DEFINED        20        21        24
    0  NTOTAL      INTEGER                  F.P.      REFS        13    DEFINED         1
   72  N1          INTEGER                            REFS        20         21        22   DEFINED        12        14
    0  TAU         REAL                     F.P.      REFS        17    DEFINED         1
    0  TIDE        REAL          ARRAY      F.P.      REFS        11         23   DEFINED         1        17        23
    0  TIDEB       REAL          ARRAY      F.P.      REFS        11       2*15        17   DEFINED         1

STATEMENT LABELS              DEF LINE     REFERENCES
   45  3010                      18           13
    0  3090                      25           22
```

```
       SUBROUTINE NCASE2      74/74    OPT=0 TRACE                      FTN 4.6+433        01/21/83  16.18.59        PAGE      2

LOOPS  LABEL     INDEX       FROM-TO      LENGTH     PROPERTIES
  57   3090      I             22 25         11B         OPT

STATISTICS
  PROGRAM LENGTH                  122B        82
```

```
SUBROUTINE NCASE3     74/74    OPT=O TRACE                 .IN 4 6+433        01/21/83  16.18.59       PAGE     1

                     SUBROUTINE NCASE3
               G                        ( TIDEB, SSTTS   NEND  DT MCAP
               B                        . TIDE, M, TAU,NCASE )
           C         ..CASE3 IS PARABOLIC INTERPOLATION FOR ) OCEANIC DATA NE O O
           C         CALLED BY
           C              INTRP2
           C         CALLS TO
           C              NCASE4
                     REAL TIDE(100) ,TIDEB(383)
                     DTAU=SSTTS
                     DTAUT=1./DTAU
                     TT1= DTAUT/2
                     TT2= TT1*DTAUT
                     TT3= TT2*DTAUT
                     M1=M+1
                     M2=M+2
                     M3=M+3
                     A=TT1*(-3.*TIDEB(M)+ 4.*TIDEB(M1)- TIDEB(M2))
                     B=TT2*(TIDEB(M)-2.*TIDEB(M1)+ TIDEB(M2))
                     IF(.NOT.(MCAP.LT.M3.OR.(TIDEB(M3).EQ.O.)))GOTO3050
                          DO 2050 N=1,NEND
                               TIDE(N)=(B*TAU+ A)*TAU+ TIDEB(M)
                               TAU=TAU+DT
             2050              CONTINUE
           C              ENDDO
                          GO TO 4090
           C          ELSE
             3050         CONTINUE
                          N=1
           C              DOUNTIL NCASE.EQ.4.OR.NEND IS FINISHED
             3070              TIDE(N)=(B*TAU+ A)*TAU+ TIDEB(M)
                               TAU=TAU+DT
                               N=N+1
                               IF(TAU.GE.DTAU.AND.(N.LE.NEND)) NCASE=4
                               IF(.NOT.(TAU.GE.DTAU.OR.(N.GT.NEND)))GOTO3070
           C              ENDDO
             4090         CONTINUE
           C          ENDIF
                      IF(.NOT.(NCASE.EQ.4)) GO TO 5010
                          TAU= TAU-DTAU
                          NBGN4=N
                          M=M+1
                          CALL NCASE4
               G                       (TIDEB, NBGN4 , NEND,SSTTS, DT
               G                       ,TT1, TT2, TT3, MCAP
               B                       , TIDE, M, TAU,NCASE)
             5010         CONTINUE
           C          ENDIF
                      RETURN
                      END
```

SYMBOLIC REFERENCE MAP (R=3)

```
      SUBROUTINE NCASE3     74/74   OPT=0 TRACE                   FTN 4.6+433        01/21/83  16.18.59        PAGE      2

ENTRY POINTS        DEF LINE      REFERENCES
    4  NCASE3              1          49

VARIABLES       SN  TYPE             RELOCATION
  236  A            REAL                               REFS        22        31    DEFINED       18
  237  B            REAL                               REFS        22        31    DEFINED       19
    0  DT           REAL                  F.P.         REFS        23        32         43    DEFINED         1
  226  DTAU         REAL                               REFS        11        34         35         40    DEFINED        10
  227  DTAUT        REAL                               REFS        12        13         14    DEFINED        11
    0  M            INTEGER               F.P.         REFS        15        16         17         18        19        22        31
                                                         42        43   DEFINED          1         42
    0  MCAP         INTEGER               F.P.         REFS        20        43    DEFINED          1
  233  M1           INTEGER                            REFS        18        19    DEFINED         15
  234  M2           INTEGER                            REFS        18        19    DEFINED         16
  235  M3           INTEGER                            REFS      2*20   DEFINED         17
  240  N            INTEGER                            REFS        22        31         33         34        35        41
                                                     DEFINED       21        29         33
  241  NBGN4        INTEGER                            REFS        43   DEFINED         41
    0  NCASE        INTEGER               F.P.         REFS        39        43    DEFINED          1        34
    0  NEND         INTEGER               F.P.         REFS        21        34         35         43    DEFINED         1
    0  SSTTS        REAL                  F.P.         REFS        10        43    DEFINED          1
    0  TAU          REAL                  F.P.         REFS      2*22        23       2*31         32        34        35        40
                                                         43   DEFINED         1         23         32        40
    0  TIDE         REAL          ARRAY   F.P.         REFS         9        43    DEFINED          1        22        31
    0  TIDEB        REAL          ARRAY   F.P.         REFS         9      3*18       3*19         20        22        31        43
                                                     DEFINED        1
  230  TT1          REAL                               REFS        13        18         43    DEFINED       12
  231  TT2          REAL                               REFS        14        19         43    DEFINED       13
  232  TT3          REAL                               REFS        43   DEFINED         14

EXTERNALS          TYPE   ARGS         REFERENCES
       NCASE4               13              43

STATEMENT LABELS              DEF LINE   REFERENCES
    0  2050                       24          21
  113  3050                       28          20
  116  3070                       31          35
  147  4090                       37          26
  202  5010                       47          39

LOOPS  LABEL    INDEX      FROM-TO     LENGTH     PROPERTIES
   75  2050     N            21 24        14B         OPT

STATISTICS
  PROGRAM LENGTH                 265B       181
```

```
SUBROUTINE NCASE4      74/74   OPT=0 TRACE                    FTN 4.6+433        01/21/83  16.18.59        PAGE      1

                    SUBROUTINE NCASE4
             G                           (TIDEB,NBEGIN,  NEND,SSTTS,DT
             G                           , TT1, TT2, TT3 ,MCAP
             B                           , TIDE, M, TAU,NCASE )
          C         ..CASE4 IS CUBIC-PARABOLIC INTERPOLATION
          C         CALLED BY
          C              NCASE3
          C         CALL TO
          C              NCASE5
                    REAL TIDE(100) ,TIDEB(383)
                    DTAU=SSTTS
                    N=NBEGIN
          C         DOWHILE N.LE.NEND
                         GO TO 7010
           2050          M1=M+1
                         M2=M+2
                         MM1=M-1
                         A=TT1*(TIDEB(M1)- TIDEB(MM1))
                         B=TT2*(2.*TIDEB(MM1)- 5.*TIDEB(M)
             1             + 4.*TIDEB(M1)- TIDEB(M2))
                         C=TT3*(TIDEB(M2)- 3.*TIDEB(M1)+ 3.*TIDEB(M)
             1             - TIDEB(MM1))
                         TIDE(N)=((C*TAU+ B)*TAU+ A)*TAU+ TIDEB(M)
                         N=N+1
                         TAU= TAU+DT
                         IF(.NOT.(TAU.GE.DTAU )) GO TO 6070
                              TAU=TAU-DTAU
                              M=M+1
                              CONTINUE
           6070          ENDIF
          C              **CHECK FOR NCASE.EQ.5
          C              M22=M+2
                         IF(.NOT.(MCAP.LT.M22.OR.(TIDEB(M22).EQ.0.)))GO TO 6075
                              NBGN5=N
                              NCASE=5
                              CALL NCASE5
             G                           (TIDEB, NBGN5, NEND
             G                           , TT1, TT2, DT
             Y                           , TIDE, M, TAU
                              N=NEND+1
                              CONTINUE
           6075          ENDIF
          C              IF(.NOT.(N .GT.NEND)) GO TO 2050
           7010     ENDDO
          C         RETURN
                    END


   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
  4  NCASE4          1            45
```

```
        SUBROUTINE NCASE4      74/74   OPT=0 TRACE                       FTN 4.6+433        01/21/83  16.18.59        PAGE      2

 VARIABLES       SN  TYPE             RELOCATION
    177   A          REAL                             REFS          23     DEFINED        18
    200   B          REAL                             REFS          23     DEFINED        19
    201   C          REAL                             REFS          23     DEFINED        21
      0   DT         REAL                  F.P.       REFS          25          36     DEFINED         1
    172   DTAU       REAL                             REFS          26          27     DEFINED        11
      0   M          INTEGER               F.P.       REFS          15          16          17        19        21        23        28
                                                        32          36     DEFINED         1        28
      0   MCAP       INTEGER               F.P.       REFS          33     DEFINED         1
    176   MM1        INTEGER                          REFS          18          19          21   DEFINED        17
    174   M1         INTEGER                          REFS          18          19          21   DEFINED        15
    175   M2         INTEGER                          REFS          19          21     DEFINED        16
    202   M22        INTEGER                          REFS        2*33     DEFINED          32
    173   N          INTEGER                          REFS          23          24          34        43   DEFINED        12        24
                                                        40
      0   NBEGIN     INTEGER               F.P.       REFS          12     DEFINED         1
    203   NBGNS      INTEGER                          REFS          36     DEFINED        34
      0   NCASE      INTEGER               F.P.    DEFINED           1          35
      0   NEND       INTEGER               F.P.       REFS          36          40          43   DEFINED         1
      0   SSTTS      REAL                  F.P.       REFS          11     DEFINED         1
      0   TAU        REAL                  F.P.       REFS        3*23          25          26        27        36
                                                   DEFINED           1          25          27
      0   TIDE       REAL       ARRAY      F.P.       REFS          10          36     DEFINED         1        23
      0   TIDEB      REAL       ARRAY      F.P.       REFS          10        2*18        4*19      4*21        23        33        36
                                                   DEFINED           1
      0   TT1        REAL                  F.P.       REFS          18          36     DEFINED         1
      0   TT2        REAL                  F.P.       REFS          19          36     DEFINED         1
      0   TT3        REAL                  F.P.       REFS          21     DEFINED         1

 EXTERNALS             TYPE    ARGS          REFERENCES
          NCASE5                  9               36

 STATEMENT LABELS                 DEF LINE     REFERENCES
     14   2050                       15            43
    111   6070                       29            26
    147   6075                       41            33
    150   7010                       43            14

 STATISTICS
   PROGRAM LENGTH                   204B        132
```

```
 SUBROUTINE NCASE5      74/74    OPT=0 TRACE                  FTN 4.6+433         01/21/83  16.18.59        PAGE      1

   1                    SUBROUTINE NCASE5
                G                       (TIDEB,NBEGIN,  NEND
                G                       , TT1 ,TT2, DT
                B                       , TIDE, M, TAU        )
   5          C         ..CASE5 IS PARABOLIC END POINT INTERPOLATION
              C         CALLED BY
                        REAL TIDE(100) ,TIDEB(383)
                        A=TT1*(TIDEB(M)-TIDEB(M-1))
                        B=TT2*(TIDEB(M+1)-2.*TIDEB(M)+TIDEB(M-1))
  10                    DO 3010 N=NBEGIN,NEND
                             TIDE(N)=(B*TAU+ A)*TAU+ TIDEB(M)
                             TAU=TAU+DT
               3010          CONTINUE
              C         ENDDO
  15                    RETURN
                        END


      SYMBOLIC REFERENCE MAP (R=3)

 ENTRY POINTS      DEF LINE      REFERENCES
    4  NCASE5          1             15

 VARIABLES      SN   TYPE             RELOCATION
    52  A           REAL                           REFS       11    DEFINED      8
    53  B           REAL                           REFS       11    DEFINED      9
     0  DT          REAL                 F.P.      REFS       12    DEFINED      1
     0  M           INTEGER              F.P.      REFS      2*8       3*9      11    DEFINED       1
    54  N           INTEGER                        REFS       11    DEFINED     10
     0  NBEGIN      INTEGER              F.P.      REFS       10    DEFINED      1
     0  NEND        INTEGER              F.P.      REFS       10    DEFINED      1
     0  TAU         REAL                 F.P.      REFS     2*11        12   DEFINED       1        12
     0  TIDE        REAL        ARRAY    F.P.      REFS        7    DEFINED      1        11
     0  TIDEB       REAL        ARRAY    F.P.      REFS        7       2*8     3*9        11    DEFINED       1
     0  TT1         REAL                 F.P.      REFS        8    DEFINED      1
     0  TT2         REAL                 F.P.      REFS        9    DEFINED      1

 STATEMENT LABELS                 DEF LINE    REFERENCES
     0  3010                         13          10

 LOOPS   LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
    33   3010      N           10 13        14B         OPT

 STATISTICS
   PROGRAM LENGTH                   100B        64
```

```
SUBROUTINE SR          74/74    OPT=0 TRACE                    FTN 4.6+433        01/21/83  16.18.59        PAGE      1

                     SUBROUTINE SR
             G                    ( ISR, JCAP, MCAP
             B                    , TIDEB, X1 )
        C            CALLED BY
        C                 INTRP1
                     DIMENSION TIDEB(383), X1(384)

        C            ..STORE TIDAL HEIGHTS(TIDEB, WITH SST SPACING)
        C            IN X1 ARRAY IN THEIR CORRESPONDING POSITIONS
                     IF(.NOT.( ISR.EQ.1)) GO TO 4010
                          JJ= JCAP-1
                          DO 3070 II=1,MCAP
                               JJII=JJ+II
                               IF(JJII.GT.383)STOP"IN SR,NEAR LABEL3070"
                               X1(JJII)= TIDEB(II)
         3070                  CONTINUE
        C                 ENDDO
        C                 **ZERO OUT( EXCESS AREA IN TIDEB)
         4010             CONTINUE
        C            ENDIF

        C            ..RESTORE TIDAL HEIGHTS(TIDEB, WITH SST SPACING)
        C            FROM X1 ARRAY
                     IF(.NOT.( ISR.EQ.2)) GO TO 6070
                          CALL MOVE( 0.0,TIDEB(1), 383)
                          IJ=JCAP-1
        C                 **RESTORE TIDE VALUES FROM X1
                          DO 6063 II=1,MCAP
                               I=IJ+II
                               IF(I.GT.383) STOP "STOPPED IN SR"
                               TIDEB(II)= X1(I)
         6063                  CONTINUE
        C                 ENDDO
         6070             CONTINUE
        C            ENDIF
                     RETURN
                     END
```

```
     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    4 SR               1           36

VARIABLES       SN  TYPE             RELOCATION
  112  I            INTEGER                           REFS       30      31  DEFINED      29
  107  II           INTEGER                           REFS       13      15       29       31   DEFINED     12      28
  111  IJ           INTEGER                           REFS       29 DEFINED       26
    0  ISR          INTEGER                 F.P.      REFS       10      24  DEFINED       1
    0  JCAP         INTEGER                 F.P.      REFS       11      26  DEFINED       1
  106  JJ           INTEGER                           REFS       13 DEFINED       11
  110  JJII         INTEGER                           REFS       14      15  DEFINED      13
    0  MCAP         INTEGER                 F.P.      REFS       12      28  DEFINED       1
    0  TIDEB        REAL         ARRAY      F.P.      REFS        6      15       25  DEFINED      1      31
```

```
      SUBROUTINE SR        74/74   OPT=O TRACE                       FTN 4.6+433      01/21/83  16.18.59      PAGE    2

VARIABLES     SN  TYPE            RELOCATION
   O  X!          REAL        ARRAY     F.P.        REFS         6        31    DEFINED       1         15

EXTERNALS          TYPE      ARGS         REFERENCES
      MOVE                     3                25

STATEMENT LABELS               DEF LINE    REFERENCES
    O  3070                       16           12
   44  4010                       19           10
    O  6063                       32           28
   76  6070                       34           24

LOOPS  LABEL      INDEX      FROM-TO      LENGTH     PROPERTIES
   26  3070    * II          12  16        15B                 EXT REFS
   60  6063    * II          28  32        15B                 EXT REFS

STATISTICS
  PROGRAM LENGTH                  136B        94
```

```
                  SUBROUTINE SSTGTD
             G                      ( K, IUNIT, IMODE, KOLD
             Y                      , X1, X2, D1, D2          )
        C         CALLED BY
        C              INTRP1
                  DIMENSION X1(384), X2(384), D1(384), D2(384)
        C         **
        C         **COMPUTE
                  I1= IUNIT+ 2*(IMODE-1)

                  I2= I1+1
                  IF(.NOT.((KOLD.GE.K).OR.(K.FQ.1).OR.(KOLD.EQ.-999))) GO TO 2010
                       REWIND I1
                       REWIND I2
           2010        CONTINUE
        C         ENDIF
                  INCK= K-KOLD
                  IF(.NOT.( INCK.LE.O.OR.KOLD.EQ.-999)) GO TO 2015
                       INCK=K+1
           2015        CONTINUE
        C         ENDIF

        C         ..POSITION THE SSTGTD FILES SO THAT THE DATA
        C         W.R.T. THE SST NUMBER K WILL GO INTO X1 AND D1 ARRAYS
                  INCK1= INCK-1
                  IF(.NOT.( INCK1.NE.O)) GO TO 4050
                       DO 4030 I=1,INCK1
                             CALL INOUT(I1, O, X1,D1, 384)
           4030              CONTINUE
        C              ENDDO
                       GO TO 4080
        C         ELSE
           4050        DO 4060 J=1,384
                             X1(J)=X2(J)
                             D1(J)=D2(J)
           4060              CONTINUE
        C              ENDDO
           4080        CONTINUE
        C         ENDIF

                  IF(.NOT.( K+1.EQ.361)) GO TO 4090
                       REWIND I1
                       REWIND I2
           4090        CONTINUE
        C         ENDIF

        C         ..PUT SSTGTD VALUES W.R.T. SST NUMBER(K+1)
        C         INTO X2 AND D2 ARRAYS
                  CALL INOUT( I1, O, X2, D2, 384)
                  RK=X1(384)
                  IK=D1(384)
                  RETURN
                  END
```

```
      SUBROUTINE SSTGTD     74/74    OPT=O TRACE                      FTN 4.6+433        01/21/83  16.18.59        PAGE      2

      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    4  SSTGTD          1           52

VARIABLES       SN  TYPE           RELOCATION
     O  D1          REAL       ARRAY     F.P.        REFS        6         28        51   DEFINED        1         35
     O  D2          REAL       ARRAY     F.P.        REFS        6         35        49   DEFINED        1
   164  I         * INTEGER                       DEFINED       27
   167  IK        * INTEGER                       DEFINED       51
     O  IMODE       INTEGER              F.P.        REFS        9    DEFINED         1
   162  INCK        INTEGER                          REFS       18         25   DEFINED        17        19
   163  INCK1       INTEGER                          REFS       26         27   DEFINED        25
     O  IUNIT       INTEGER              F.P.        REFS        9    DEFINED         1
   160  I1          INTEGER                          REFS       11         28        49   DEFINED        9
                                                  I/O REFS      13         42
   161  I2          INTEGER                       DEFINED       11    I/O REFS       14        43
   165  J           INTEGER                          REFS     2*34       2*35   DEFINED        33
     O  K           INTEGER              F.P.        REFS     2*12         17        19        41   DEFINED        1
     O  KOLD        INTEGER              F.P.        REFS     2*12         17        18   DEFINED        1
   166  RK        * REAL                          DEFINED       50
     O  X1          REAL       ARRAY     F.P.        REFS        6         28        50   DEFINED        1         34
     O  X2          REAL       ARRAY     F.P.        REFS        6         34        49   DEFINED        1
        VARIABLES USED AS FILE NAMES. SEE ABOVE

EXTERNALS            TYPE    ARGS          REFERENCES
        INOUT                  5                28         49

STATEMENT LABELS                DEF LINE    REFERENCES
    40  2010                       15           12
    54  2015                       20           18
     O  4030                       29           27
    75  4050                       33           26
     O  4060                       36           33
   110  4080                       38           31
   121  4090                       44           41

LOOPS   LABEL     INDEX        FROM-TO      LENGTH     PROPERTIES
    64  4030    * I             27 29          7B                    EXT REFS
    76  4060      J             33 36         11B           OPT

STATISTICS
  PROGRAM LENGTH                   212B        138
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